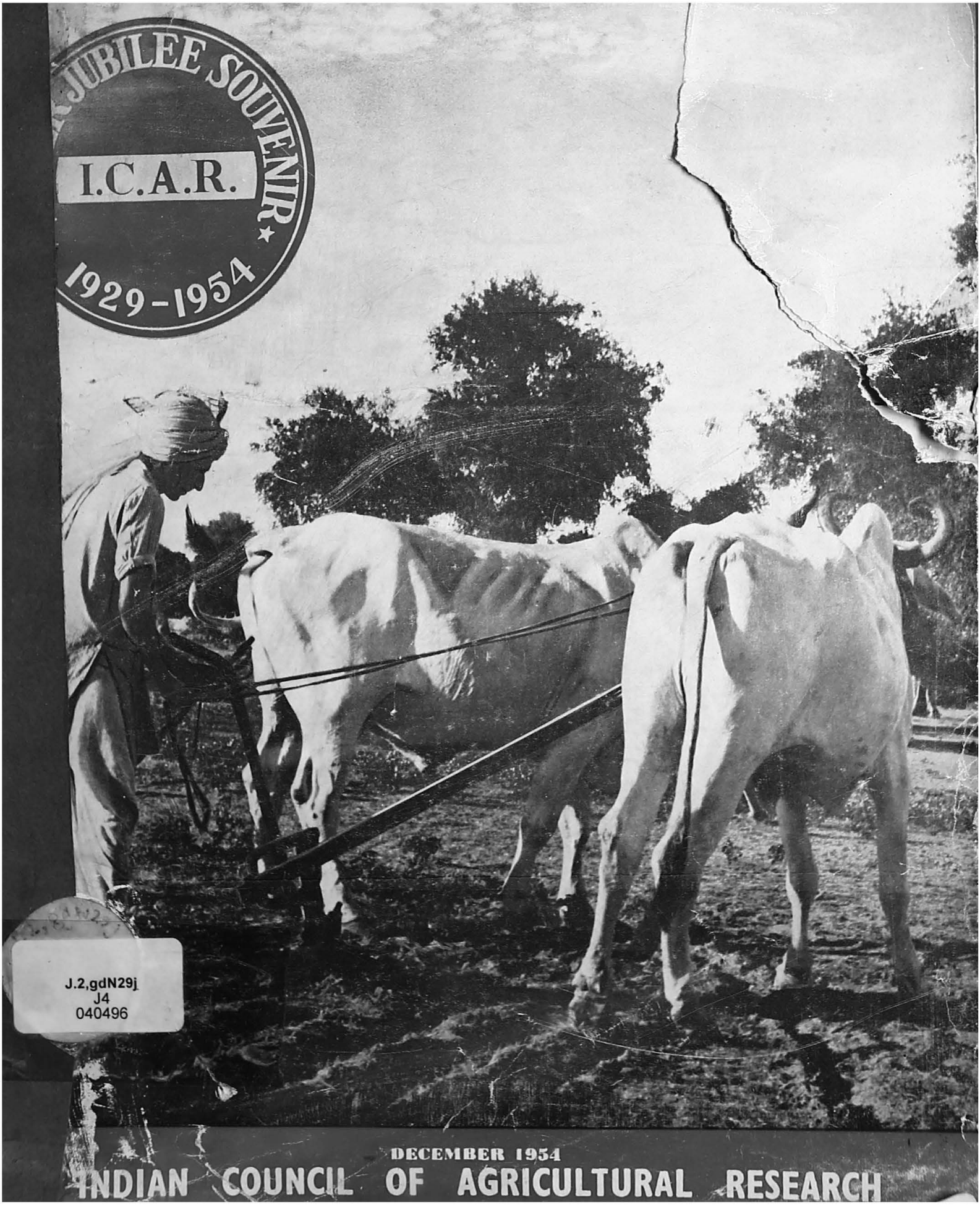

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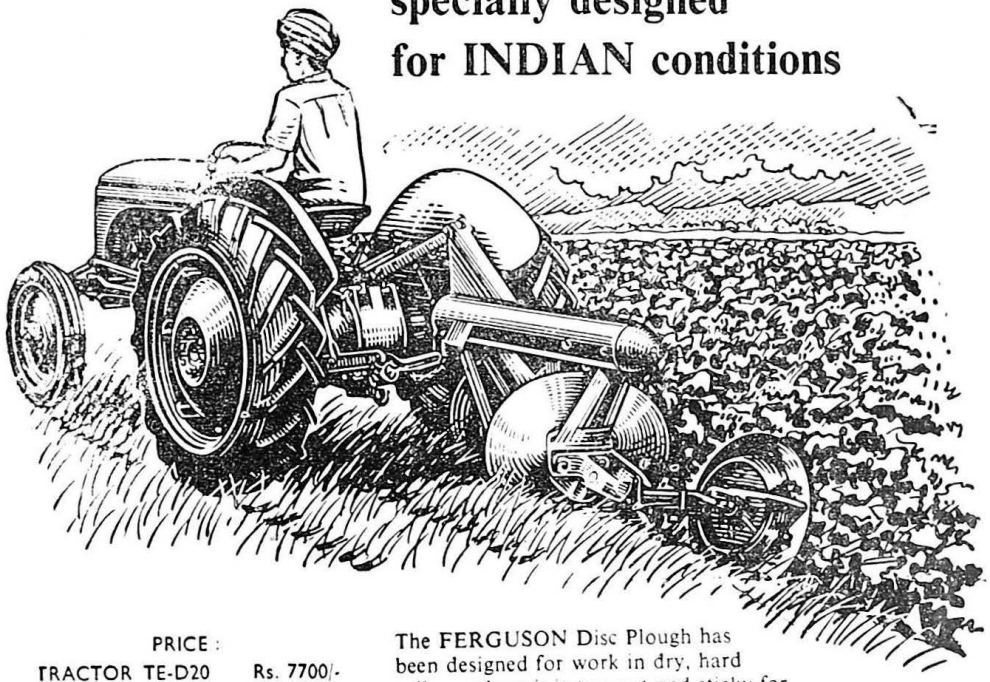

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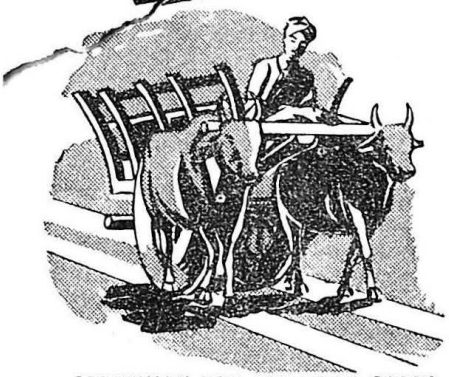

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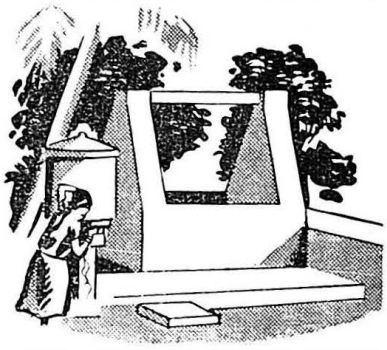

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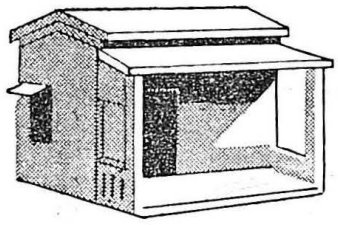

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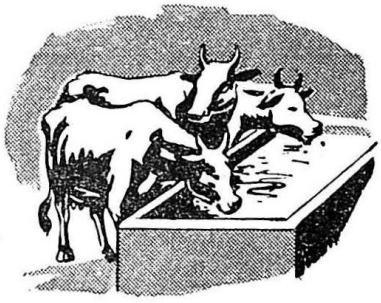

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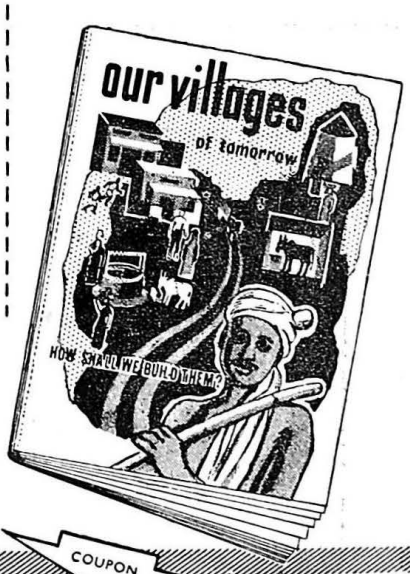

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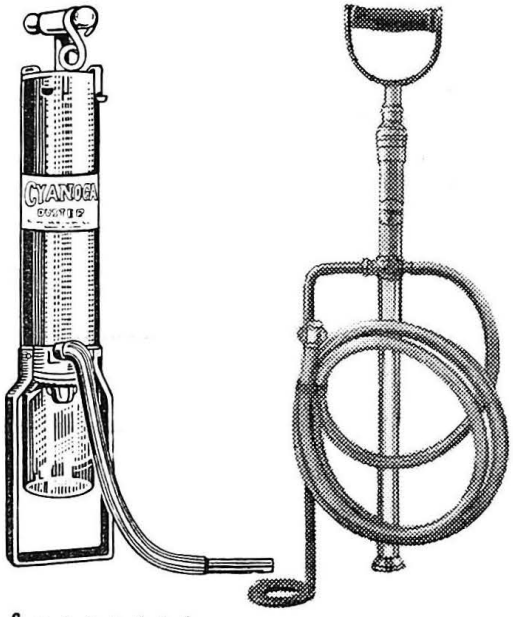

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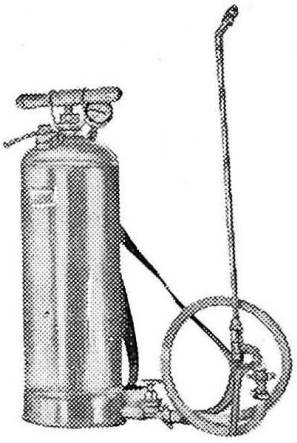

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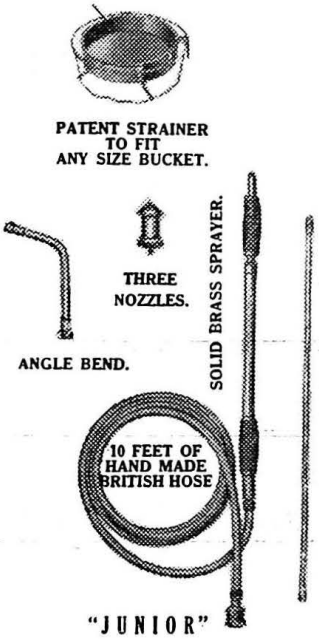

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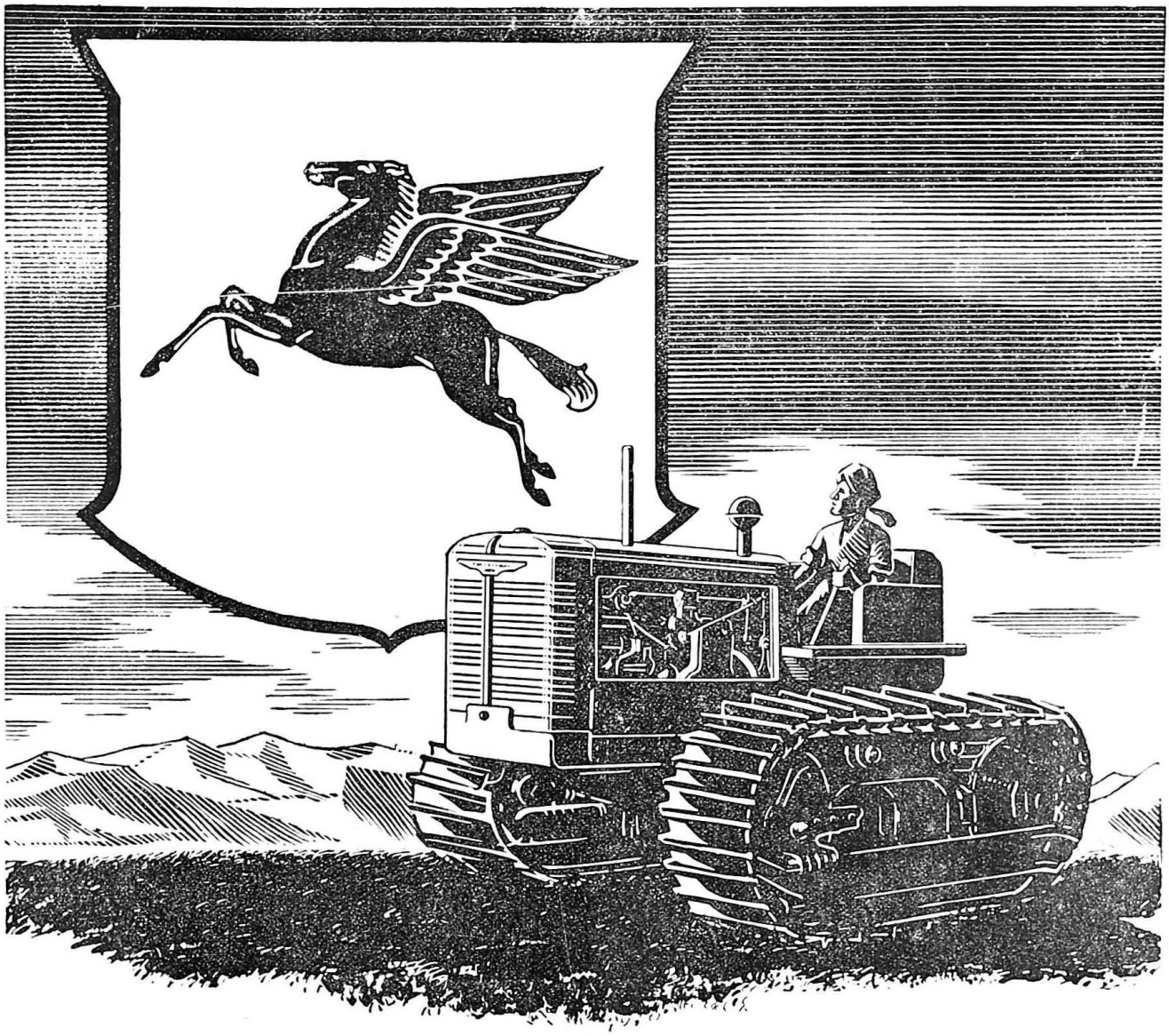

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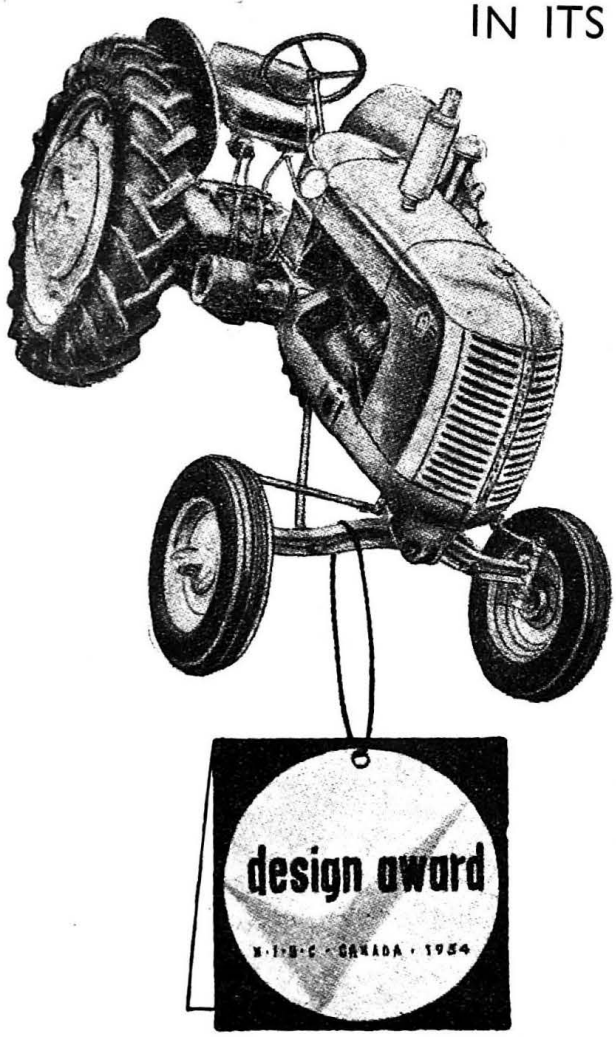

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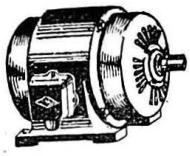

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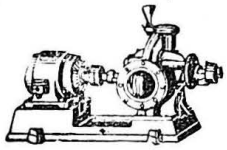

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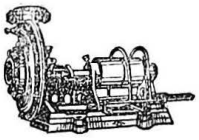

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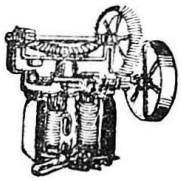

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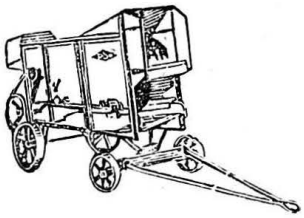

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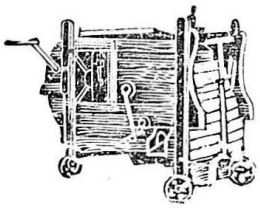

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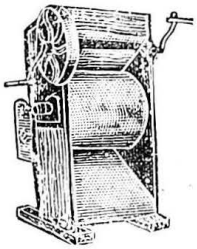

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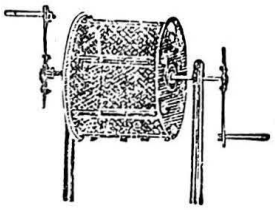

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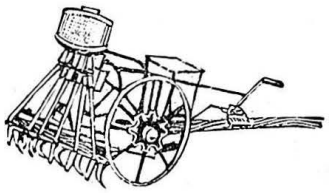

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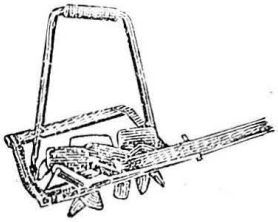

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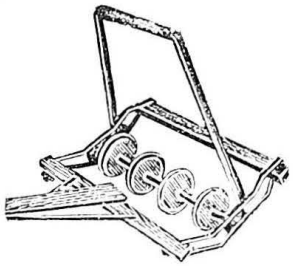

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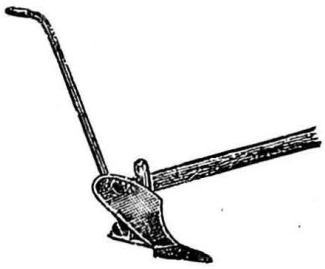

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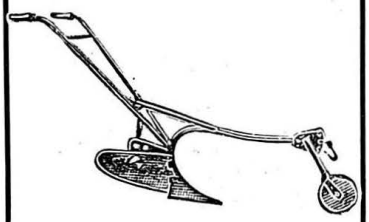

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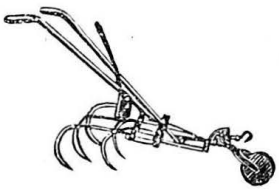

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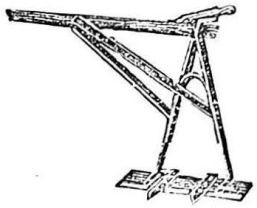

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NEW DELHI

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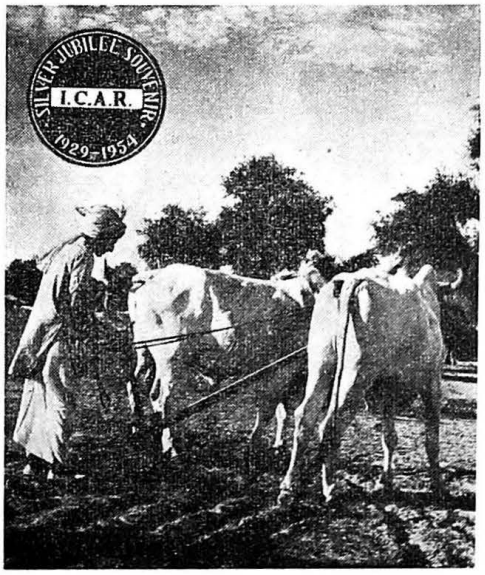

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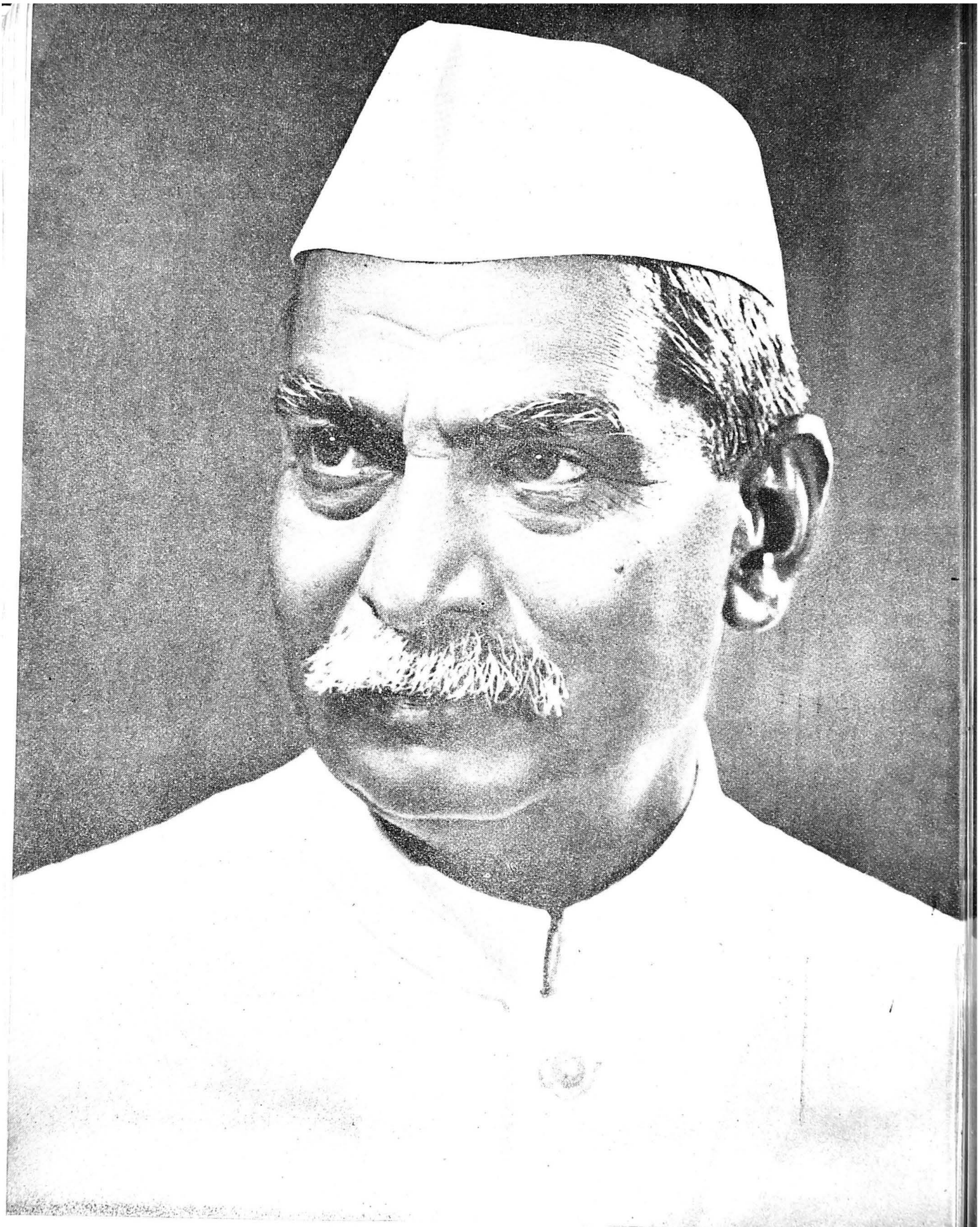


DR. RAJENDRA PRASAD

Message from the President of India

RASHTRAPATI BHAVAN,
NEW DELHI.

2nd December 1954.

The Indian Council of Agricultural Research has now completed 25 years of its useful career. Having been associated with the institution as its President when I was Minister for Food and Agriculture, I am naturally proud of its achievements. This Souvenir Volume and the Research Supplement which are now being published to commemorate the Silver Jubilee of the Council will, I am sure, give the public an idea of the remarkable progress made by the Council in the field of agricultural research and will, I hope, focus the attention of the people on the various important problems which the Council is tackling for the improvement of our agriculture. Since the establishment of the Council in 1929 as a result of the recommendation of the Royal Commission, agricultural research has received great impetus, and considerable scientific knowledge regarding agriculture and animal husbandry is now available, enabling us to increase our food production, to eradicate and control diseases like rinderpest, to provide improved varieties of seed, to improve the breed of cattle, etc., and the importance of all this cannot be too much emphasized in a country like ours which is predominantly agricultural. I wish the Council of Agricultural Research many, many years of useful existence.

Rajendra Prasad

FOREWORD

India is mainly an agricultural country. Nearly three-fourths of its population are dependent directly on agriculture for a living. Therefore, any improvement in agriculture is intimately linked with the joy and happiness of the people of this country.

It will appear strange that, although agriculture happens to be such an important factor in the life of its people, any definite governmental policy for its improvement did not exist in this country before 1903. In that year a scheme was initiated for the establishment of a central agricultural research institute at Pusa. It was thought, however, that such an institution would not be of much help without simultaneous development of agriculture in the then existing provinces. Accordingly it was decided in 1905 that suitable steps should be taken for the development of agriculture, agricultural research and education throughout the country. In pursuance of this policy agricultural colleges were established in several provinces. Veterinary research, however, had received prior attention. A central institute for veterinary research was established as early as 1889 in Poona and subsequently shifted to Mukteswar in 1893.

In 1919 constitutional changes took place and, as a result, agriculture became a provincial subject. The absence of an agency to co-ordinate research at the Centre and in the provinces, and also between the different provinces themselves, was soon realised. Accordingly in 1928 a Royal Commission was appointed to report on conditions of agriculture and rural economy in this country. The Commission felt that it was necessary to set up an organisation to effect liaison between the Centre and the provincial institutes. It, therefore, recommended the establishment of a central council of agricultural research and thus the Imperial (now Indian) Council of Agricultural Research was brought into being as a statutory body in 1929. Later developmental and extension work were also brought within the scope of its activities. The aims and objects of the Council are:

(*i*) to undertake, aid, promote and co-ordinate agricultural and animal husbandry education and research ;

(*ii*) to act as a clearing house of information not only in regard to research, but also to agricultural and veterinary matters generally ;

(*iii*) to establish and maintain a research and reference library in pursuance of the objects of the Council with reading and writing rooms and to furnish the same with books, reviews, magazines, newspapers and other publications ; and

(*iv*) to do all other things which the Council may consider necessary, incidental or conducive to the attainment of its objects.

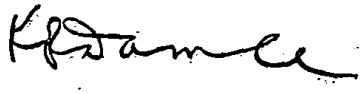
According to the Constitution of the Council, the Minister of Food and Agriculture, Government of India, is its President. A Vice-President is also provided who is its chief executive officer and who also acts as Agricultural Advisor to the Central Government.

The Council does not have any research institute of its own but finances approved research work carried out in Government Institutes, belonging to the Centre and the States, in Universities and also in recognised private institutions. Since the establishment of the Council its work has grown both in volume and importance. Beginning with a few research schemes at the time of its establishment, it now finances a large number of research projects both in agriculture and animal husbandry; the expenditure incurred so far by this Council totals more than 338 lakh of rupees.

The Council has now established itself, as was intended at the time of its establishment, as the supreme agricultural organisation, which guides, finances and co-ordinates research problems connected with agriculture and animal husbandry in this country in the widest sense of the term. Its activities are not only limited to research projects, but also include extension and development. It also undertakes training of students in agricultural and animal husbandry statistics and has helped to build up a school of research in this field. In addition, it has set up two councils, one on agricultural and the other on animal husbandry education to deal with educational matters relating to agriculture and animal husbandry in this country.

In order to disseminate the results of research, the Council publishes a number of journals, monographs, bulletins, pamphlets, etc. The publications range from technical communications, useful only to trained research workers, to non-technical ones, written in a popular manner and simple language, for the benefit of the layman. In addition the Council has also taken recourse to various types of audio-visual aids in disseminating useful information. The Council thus ensures that the results of research programmes sponsored by it can reach both the research personnel engaged in laboratories and trial farms as well as the farmer working on his field.

The Council has completed its twenty-fifth year of service of the country. It is celebrating its Silver Jubilee. It is appropriate on this occasion, therefore, to inform the people in this country about the activities and the achievements of this Council during the last 25 years. An attempt has been made in the following pages to indicate some of the important work sponsored by the Council during the last quarter of a century.



(K.R. Damle)
Vice-President,
Indian Council of Agricultural Research

New Delhi:
December 14, 1954

Organisation of Agricultural Research in India

by

B. N. Uppal

"THE basis of all agricultural progress is experiment." It was in the beginning of this century that the Government of India recognised the need for the establishment of a sound system of scientific investigation in connection with agriculture. In 1903, Government laid the foundation of organised research in India by the establishment of an agricultural research station and an experimental farm at Pusa in Bihar, with the help of a donation of £30,000 made by an American gentleman, Mr. Henry Phipps of Chicago. Subsequently, funds were provided for the development of agricultural research, experiment and education in the provinces, and a separate department of agriculture was constituted in most of the States.

The constitutional changes of 1919 resulted in the transfer of the subject of agricultural research, education and development to the provinces, and the Government of India's responsibility for agricultural improvement in the country was limited to the administration of the central research institutes. Although it was originally intended that the central institutes under the control of the Government of India should be the apex of an efficient research organisation in the country, no provision was made in the Government of India Act of 1919, for co-ordination of the work of central institutes with that of similar institutions in the provinces. The stage was thus set for a general enquiry into the functions which a central organisation should perform in the development of agricultural research. In 1926, the Royal Commission on Agriculture in India was appointed to examine and report on the conditions of agriculture and rural economy in India, with particular reference to the investigation, among other things, of the measures being taken for the promotion of agricultural and veterinary research, experiment, demonstration and education.

Central organisation

As a result of the recommendations of the Royal Commission on Agriculture, the Imperial (now Indian) Council of Agricultural Research was constituted in 1929, with the primary object of promoting, guiding and co-ordinating agricultural research throughout India. The Commission had hoped that, "through the proposed Council of Agricultural Research, it would be possible to develop satisfactorily agricultural research in India, to secure a continuity of policy and to ensure a programme of ordered advance in the domain of agricultural research". Indeed, in modern times rapid advancement of science is possible only when it is properly organised.

The Council has a Governing Body and an Advisory Board. The Governing Body has executive functions and manages the funds of the Council. The Advisory Board is "charged with the responsibility for examining all proposals in connection with the scientific objects of the Council", and is assisted by the Board of Research and the Scientific Committees in planning, co-ordinated research in agriculture and animal husbandry. The Scientific Committees are constituted on a wide basis and include well-knowrn research workers representing the State Agricultural Departments, the universities and other scientific institutions. They make recommendations regarding the suitability of research projects submitted to the Council for financial assistance, and suggest detailed arrangements necessary to ensure the effective implementation of the research programmes. On the basis of these recommendations, the Research Board, which consists of the chairmen of the Scientific Committees and the representatives of the State Agricultural Departments, draws a broad picture of the agricultural research in progress in the country and suggests the lines on which research should, in future, be organised. In the development of a co-operative plan of research between the Central Government and the State Agricultural Departments, it is doubtful whether we have yet succeeded in building up a system of co-operative agreement which has grown up in the U.S.A., and "which has proved one of the most effective devices for correlation in the whole field of governmental research" in that country.

Although the co-ordination of agricultural research work throughout the country is the primary function of the Council, it does not maintain any research institutions directly under its control. If a particular research project is of all-India or regional importance, the Council, in consultation with its Scientific Committees, decides whether it should be carried out at a central institute or at some State research stations with due regard to the facilities available at the stations. In ordinary circumstances, expenditure on a research project is shared equally by the Council and the State Government, but if fundamental problems of importance to the whole of the country are to be investigated, the Council has always been willing to meet the full cost of such investigations.

As stated above, agricultural development is a subject which falls within the purview of the State Governments, and the Government of India renders substantial assistance to agricultural progress by the promotion of research. Accordingly, the Central Government is maintaining under its control a number of research institutes for fundamental research on agricultural and animal husbandry problems. These institutions are the Indian Agricultural Research Institute, New Delhi (transferred from Pusa after the disastrous earthquake of 1934) ; the Sugarcane Breeding Institute, Coimbatore; the Central Rice Research Institute, Cuttack ; the Central Potato Research Institute, Patna ; the Indian Veterinary Research Institute at Izatnagar and Muktesar ; and the Indian Dairy Research Institute, Bangalore. Some of the fundamental and advanced research carried out at these institutes has yielded results of great practical value and has justified their existence in the minds of the general public. However, until a machinery for the development of the research programmes of these institutes in co-operation with the State research stations is created, the central institutes will not be able to make their full contribution to the agricultural progress of the country.

The organisation of soil conservation work in this country is in the hands of the State Governments. The co-ordination of such work between the States is achieved through the agency of the Central Soil Conservation Board which has recently been set up. The functions of this Board include the organisation, co-ordination and initiation of research in soil conservation, the arrangements for the training of State technical officers in soil conservation, collaboration between the State and the Centre in the promotion of soil conservation research, and provision of financial assistance for projects undertaken in the States and the River Valleys. The Government of India have recently decided to establish seven research-*cum*-training centres at the following places:

(i) Bellary for black soil region,

(ii) In the Nilgiris,

(iii) Kotah for reclamation of ravine areas, with a sub-station in North Gujarat,

(iv) Hazaribagh for River Valley areas,

(v) Dehra Dun for studying problems of afforestation in the Sivalik Hills, with a sub-station at Chandigarh for training of *chos* (hill torrents),

(vi) Jodhpur for afforestation in the Rajasthan Desert,

(vii) Bidar (in the Hyderabad State) for studying erosion problems of lateritic areas.

In addition to the central institutes, there is a number of crop or commodity committees which confine themselves to research on particular commodities. The research work carried out by these committees is supplementary to the work of the State Agricultural Departments on these crops. Each commodity committee is financed by a cess levied on the commodity concerned or by a grant made by the Government of India. Agricultural research in the commodities is provided for by grants to the State Agricultural Departments for specific investigations. Government has constituted commodity committees for cotton, jute, sugarcane, oilseeds, tobacco, arecanut, coconut and lac. There are boards which watch over the interests of all branches of the trade in rubber, tea and coffee. Whilst there may be no objection to organising agricultural research on plantation crops on a crop basis, it is sometimes seriously contended that the promotion of research on crops like cotton has actually resulted in the neglect of the other crops grown in rotation. There may have been some force in this argument in the past, but the newly constituted Research Board of the Indian Council of Agricultural Research will, in future, provide the necessary link between the research work on cotton and that on its rotation crops.

State organisation

The work of the State Agricultural Departments is to ascertain by experiment and research the methods by which agricultural production can be increased and improved in quality, and to get these methods adopted

in general farming practice. The functions of the agricultural departments may be classed under four main headings, *viz*, research, agricultural education, demonstration, and supply of agricultural requisites, *i.e.* seeds, manures, implements, etc.

The Director of Agriculture is the head of the Agricultural Department and is responsible for all agricultural activities in the State. He is assisted in his work at headquarters by a Joint Director of Agriculture for extension and, in some cases, by a Joint or Deputy Director of Agriculture for research. Whilst the duty of the Joint Director for extension is to organise and systematise extension activities throughout the State, the Joint or Deputy Director for research coordinates the work of research workers stationed at the agricultural college and those in charge of experimental farms in the State.

There are agricultural colleges in most of the larger States, and they are affiliated to the State universities. The Principal exercises full control over the teaching given in the college. The heads of sections of the college are largely engaged in research work, but also do some teaching in their special subjects. The college thus combines the functions of teaching with those of research and serves as the central experiment station of the agricultural department. The heads of sections also function as extension (or "subject matter") specialists in their respective sciences, *viz*., agronomy, soils, horticulture, animal husbandry, entomology, plant pathology, agricultural engineering, etc.

Finance

Agricultural research in this country is financed from the following sources:—

		Rs. (lakhs)	
(1)	Grants made by the Government of India:		
	(a) For the central research institutes	72.8	
	(b) For the commodity committees on sugarcane, arecanut, coconut, oilseeds and tobacoo	32.6	
	(c) For the Central Soil Conservation Board	*50.0	
	Total	155.4	155.4
(2)	Proceeds from cess or export duty levied on agricultureal commodities:—		
	(a) On tea ..	60·0	
	(b) On coffee ..	0·5	
	(c) On rubber ..	1·7	
	(d) On lac ..	7·41	
	(e) On cotton ..	10·20	
	(f) On jute ..	10·00	
	(g) On miscellaneous commodities ..	42·00	
		132·31	132·31
(3)	Grants made by the State Governments ..		**500·00
			787·71

The funds of the Indian Council of Agricultural Research are derived from an export cess levied on certain agricultural commodities under the Agricultural Produce Cess Act of 1940. The income from the levy of this cess in 1953-54 was estimated at Rs. 49·40 lakhs. Since its inception in 1929, the Council has spent the following amounts on agricultural research:

	Rs. (lakhs)
(1) Expenditure on research projects completed by the 31st March, 1953	141·91
(2) Actual expenditure on current research projects up to the 31st March, 1953	124·72
(3) Estimated expenditure on current research projects in 1953-54	72·11
Total up to the 31st March, 1954	338·74

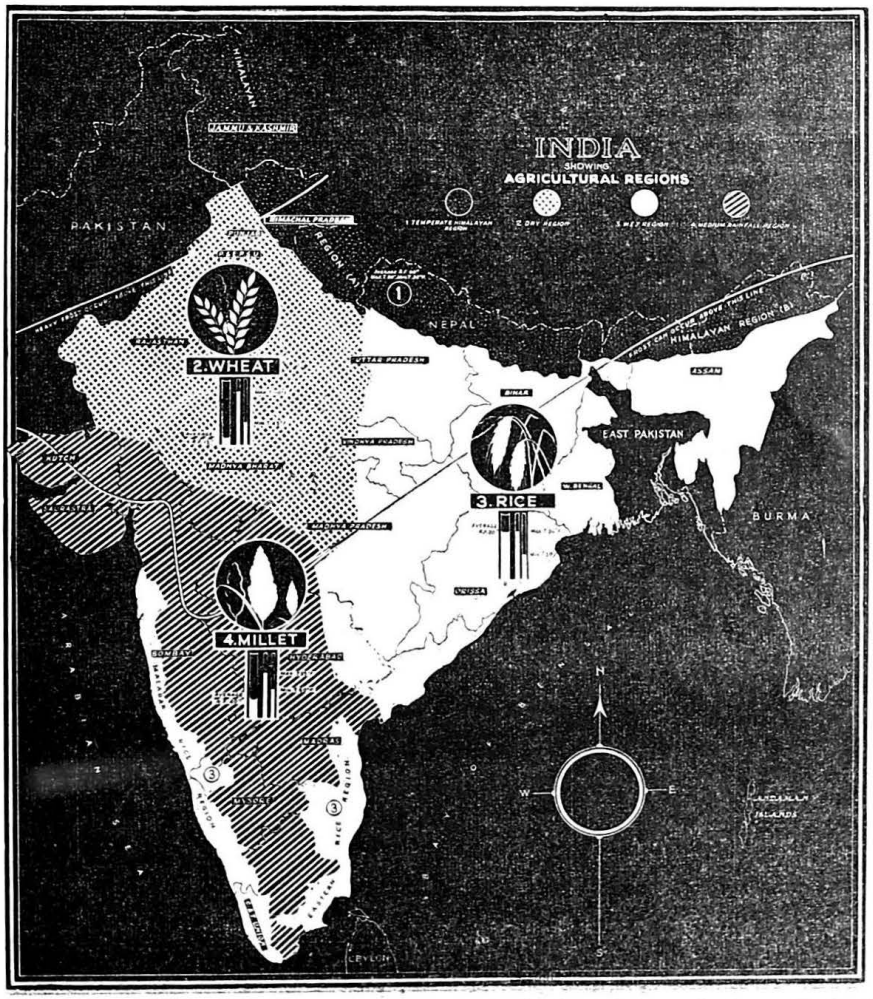
As against an annual provision of about Rs. 8 crores for agricultural research in India, the annual expenditure on agricultural research in the U.S.A. amounts to Rs. 55 crores approximately, and is met from the following sources:

	Dollars (million)
(1) Federal grants to States	12
(2) State appropriations	50
(3) Federal appropriations to the U.S. Department of Agriculture	50
Total	112

* A provision of Rs. 5 crore per annum is likely to be made in the next Five-Year Plan (1956-61) for expenditure on soil conservation projects under the auspices of the Central Soil Conservation Board.

**The amount of Rs. 5 crores includes the provision of Rs. 3 crores made by the Planning Commission for agricultural research in the States in the First Five-Year Plan. Figures of expenditure on agricultural research other than the provision of Rs. 3 crores made by the Planning Commission as stated above, are not easily available, but this provision is not likely to be less than Rs. 2 crores per annum.

AGRICULTURE



Yield trial with Chinese variety of paddy

Rice

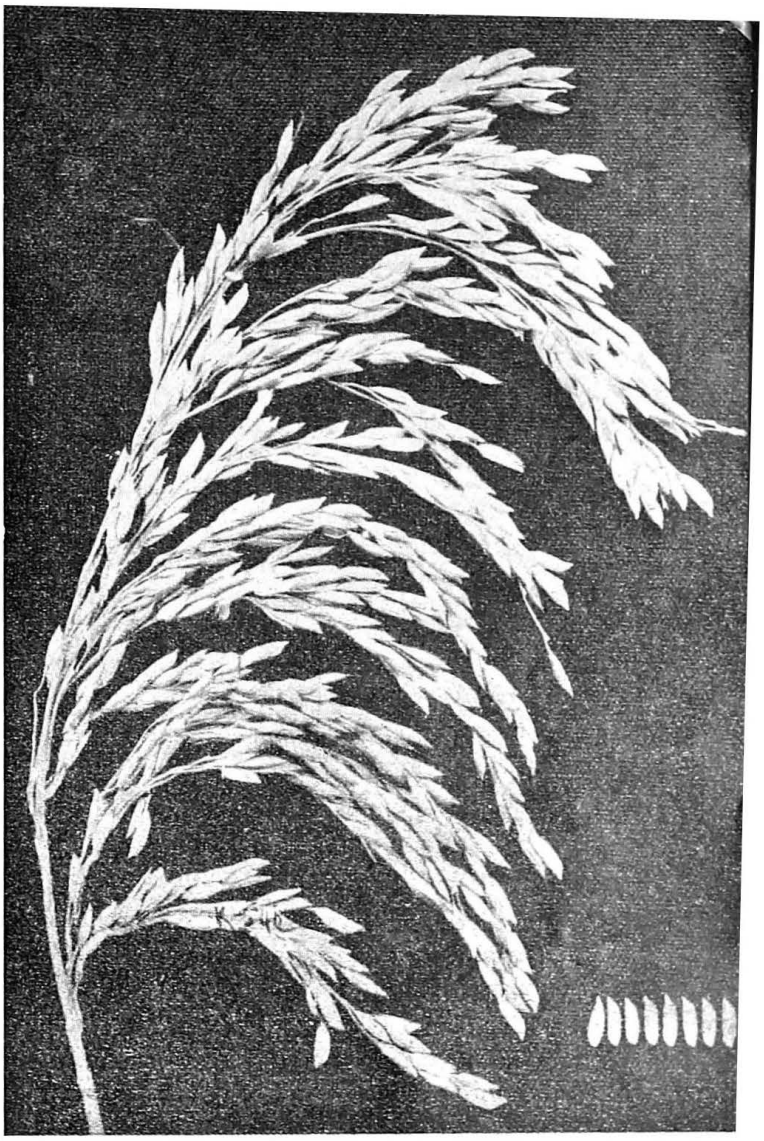
by

N. Parthasarathy

RICE is grown throughout the country as far north as the Kashmir Valley and forms the staple food of the majority of the population. It occupies an area of about 73 million acres and the production is about 22 million tons of clean rice. The State Agricultural Departments, on their formation in the beginning of this century, devoted special attention to the improvement of this crop. Initially, the work of simple selection and purification of the local varieties was taken up with satisfactory results. Attention was also paid to the cultural practices and particular emphasis was laid on the transplanting of the crop as against direct sowing and growing of thin nurseries. Later breeding work on scientific lines was started including hydridization to combine the desirable characters of different varieties. As a result of this intensive breeding programme, several improved varieties were evolved. Besides, a substantial progress was made in the study of the inheritance of various characters and thus a considerable contribution was made to the fundamental knowledge of the genetics of rice.

The Indian Council of Agricultural Research since its inception in 1929, laid much stress on the all-round research on this important crop and has been subsidising a large number of research schemes for the improvement of rice crop, and has helped to bring about a co-ordination of rice research in progress in different parts of the country.

The Government of India established the Central Rice Research Institute at Cuttack during the year 1946 for carrying on fundamental research on the various aspects of rice crop, the results of which would have wide applicability.



Earhead of "Chanchala"—premier Kolamba strain (Bombay)

Breeding for high yield

The results of breeding for high yield carried out in the country have been spectacular and a large number of improved varieties, giving on an average an enhanced yield of 10-15 per cent have been obtained.

Because of the varying soil and seasonal conditions and water facilities in different rice tracts, it is not possible to have cosmopolitan varieties which could thrive well under different conditions. Accordingly, it is necessary to breed varieties suitable for different conditions and a large number of improved strains have been evolved. These superior varieties numbering about 284, as indicated below, for the whole country are mostly isolations from naturally variable populations, only 27 being produced by hydridization.

High yielding varieties produced in the more important rice growing States of India

State	Rice area million acres (1949—50)	Improved varieties			Total	Yield of unhusked rice (lb. per acre)
		Selection from natural population	Evolved by hybridization	Introductions		
Bihar	13·8	7			7	1,830—2,050
Madras	10·6	91	10		101	1,800—4,200
West Bengal	9·7	48	5	1	54*	1,500—3,400
Orissa	9·5	20			20	2,200—3,200
Uttar Pradesh	9·0	17	3	1	21	2,000—3,400
Madhya Pradesh	8·8	14	5		19	1,100—2,000
Assam	4·0	38	3		41*	1,760—3,920
Bombay	3·0	20	1		21	2,000—2,700

* Total number of improved varieties evolved in undivided Bengal and Assam

Breeding for earliness

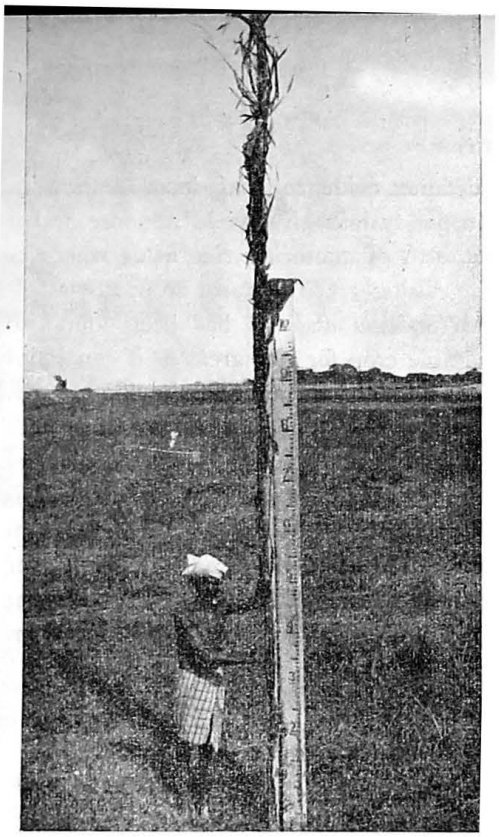
There is enormous variation in the life periods of rice varieties grown in India, ranging from 80-200 days. For uplands, hilly tracts and in areas where the rainfall is precarious, it is essential to grow early maturing varieties. So also in double cropped areas where two crops of rice are grown on the same land during the year. Therefore, earliness is an extremely valuable character and almost in all States efforts have been made to combine earliness with high yields. Early maturing varieties from Russia, China and other countries have also been imported for trial. Except for some Chinese varieties, others though maturing early, gave poor yields. Two of the Chinese varieties have been found to be well adapted to the higher altitudes in the Kashmir Valley, where they have given yields of 5,000-65,000 lb. per acre and mature 4-6 weeks earlier than the local varieties. Their cultivation is rapidly extending in the Valley. These Chinese varieties are also being extensively tested in other rice growing areas. Vernalization for inducing earliness was tried and some interesting results were obtained at Calcutta University. It was found that the short day treatment induced earliness in winter (*aman*) varieties.

Line planting of rice

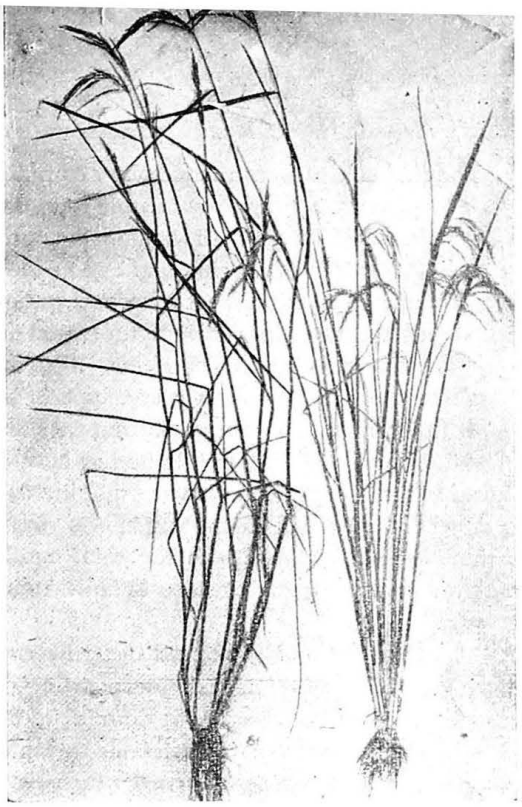
Breeding for disease resistance

Important diseases of rice have been studied and breeding for disease resistance has received much attention. Breeding for blast disease caused by *Piricularia oryzae* has been carried out in Madras State and range of varities highly resistant to *Piricularia* with the desirable agronomic characters has been produced with the co-operation of breeders and mycologists. Two new varieties, *viz*, Co.25 and Co.26 of Madras are notable examples. Work on the disease caused by *Helminthosporium* has been carried out in West Bengal and encouraging results have been obtained. Intensive studies on all aspects of breeding for disease resistance are in progress at Central Rice Research Institute, Cuttack, and other stations in the States.

Investigations on another important disease, *viz*., foot-rot (*Fusarium moniliforme*) which occurs in a severe form in South India and Assam can be effectively controlled by treating seed with organo-mercury compounds.



Deep water rice (Assam)



Deep water rice *Normal rice*

Problem of wild rice

Natural hybrids between the cultivated varieties and the wild rice *O. sativa* var *fatus* occur as weeds in cultivated fields and cannot be distinguished until the earheads appear, when spikelets shatter even before the grains are ripe. This problem of wild rice exists in States of Madhya Pradesh, Bombay, Bihar, Punjab and Orissa. Investigations into eradication of the wild rice were carried in Madhya Pradesh, and pigmented hybrid varieties have been evolved for cultivation in the States. The hybrid with wild rice could be easily identified in the early stages and removed.

Deep water and saline rices

About 4½ million acres in India are subjected to floods and salt water inundation. Flood resistant varieties suitable for growing in varying depths of water ranging from 4 ft. to 20 ft. have been evolved in Assam, Uttar Pradesh and Orissa. A saline resistant variety SR26B evolved in Orissa is also found to be promising in the Madras State. Physiological studies in Orissa have shown that tolerance to submergence and salinity may be induced by certain pre-treatment of seeds.

December 1954

T. 90—an improved type of paddy

Improvement in cultural practices

The rice cultivation practices vary considerably from place to place according to the soil type, rainfall, etc. Therefore, experiments to determine the optimum time of sowing, seed rate, spacing and age of seedlings have been conducted at various experimental stations. It has been found that plantings early in the season during May-June are conducive to higher yields. Spacing and rate of planting depend on the variety, type of soil and the time of planting. For early maturing varieties a spacing of about 6 × 6 inches is found to be the best and for long duration varieties a wider spacing of 9 in. × 9 in. × 12 in. is desirable. Too wide a spacing affects yields adversely owing to the reduction in the total number of ears and number of grains per ear in unit area.

The experimental results all over the country indicate the definite superiority of transplanting over broadcast sowing, the increase being from 15 to 30 per cent. Besides, there is economy in seed—for transplanting only 20-25 lb. of seed per acre is used which is about one-third of what is used for broadcasting and the expenditure on weeding is much less.

Manuring practices

Manuring of rice crop is the most effective method of increasing rice production and a large number of experiments with different manures and fertilisers have been conducted in different soil and climatic regions by the State Agricultural Departments. The results indicate that the application of nitrogen either in organic or inorganic form gives an appreciable increase in yield; the responses, however, vary in different places according to rate, method of application, the nature of the soil and its hydrogenion concentration, climate, moisture supply and other environmental conditions. While the application of nitrogen has given universal response, the application of phosphate has given only a limited response in certain places and potash gives no response.

Inorganic nitrogenous fertilisers

Of the inorganic nitrogenous fertilisers tested, ammonium sulphate has proved to be the most effective. The available data indicates that the ammoniacal forms of nitrogen are more efficient than the nitrate forms. Experiments conducted at the Central Rice Research Institute and other places with graded doses of ammonium sulphate upto 120 lb. N per acre indicate that application up to 40 lb. N per acre gives an economic response. A dose of 20 lb. N or 100 lb. ammonium sulphate can be universally recommended till more experimental data on the response of different soils to varying applications is available.

Green manures

There is definite evidence that incorporation of green matter in paddy soils gives yield response and it is the cheapest form of manuring rice fields wherever the facilities for raising green manure crops are available. *Dhaincha* (*Sesbania aculeata*) has been found to be the most suitable crop for rice areas as it can stand the soil and water conditions prevailing in these areas. In Kashmir Valley, green manuring of rice crop with lentil (*Lens esculentin*) has been found to be more effective and in Uttar Pradesh sann-hemp (*Crotalaria juncea*) is becoming more popular. Large varieties of crops grown in various countries have been collected and are under examination for their usefulness as green manure; *Pheseolus semi-erectus*, imported from Indonesia, has been found very promising.

Nitrogen fixation

Investigations were carried out to determine the role of blue green algae in rice nutrition and its effect on the fertility of soil. The results indicate that fixation of atmospheric nitrogen in water-logged rice soils is an algal process and there exist a symbiotic relationship between the rice plant and certain blue-green algae. The growth of certain blue green algae in rice fields, particularly *Anabaena sp.*, stimulates the plant growth and improves the nitrogen status of the soil.

Recent trends

As a result of intensive research on this crop for the last four decades, useful results have been obtained and a large number of varieties have been evolved. Proper manuring of rice fields has been stressed as it has been found that full benefits from improved varieties can be ensured only when these are grown under well manured conditions.

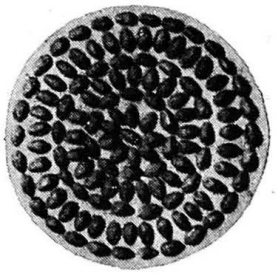
It is further realised that under the intensive methods of cultivation and manuring, rice varieties capable of giving higher field responses should be grown. With this aim in view, intensive hybridization programme between *japonica* and *indica* varieties of rice has been started. The *japonica* varieties are high yielders, give a better response to intensive manuring and possess short, non-lodging straw, while *indica* varieties have a better tillering capacity and are resistant to disease and adverse climate conditions. The hybrid progenies from such crosses will be further studied in various rice-growing States for evolving types suitable for different regions.

Wheat Barley and Oats

by

B. P. Pal

N. P. 809 resistant to all the three types of rust



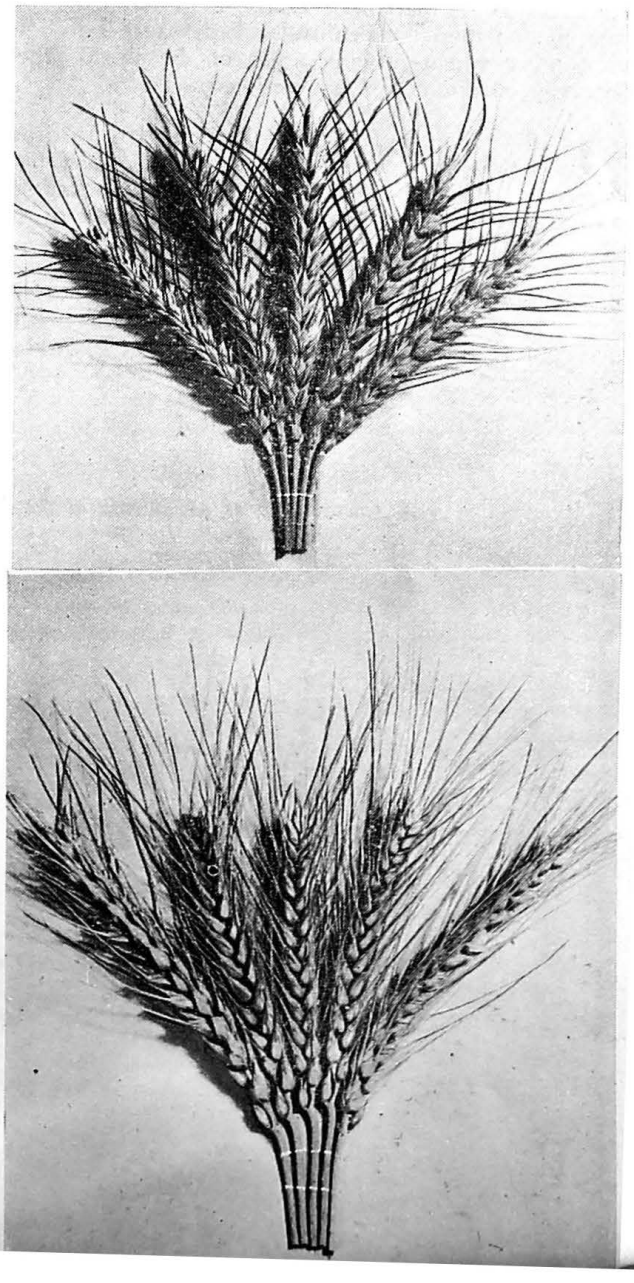
Ear samples of the improved wheat N. P. 770, a promising variety for the hills

IN India, at the present time, about 24 million acres of wheat are grown. Wheat grains discovered as a result of the Mohen-jo-daro excavations, and also other evidences, indicate that North-Western India was one of the ancestral lands of this cereal, which in its world importance as a staple food is rivalled only by rice.

Wheat breeding

Perhaps the earliest researches carried out on the wheat crop in India were those in the field of wheat breeding. Important pioneering work was done by the Howards during the first decade of this century, at the Agricultural Research Institute at Pusa in Bihar.* Similar work has been taken up in the different wheat-growing States of the country. Among the outstanding achievements of this work may be mentioned varieties like N.P. 4, N.P. 52, N.P. 125 and N.P. 165 of the Indian Agricultural Research Institute, Kanpur 13 of Uttar Predesh, A.O.68, A.O.90, and A. 115 of Madhya Pradesh, Bansi 224, Jay, Vijay and Niphad-4 of Bombay and 8-A, 9-D, C. 518 and C. 591 of Punjab. These wheats gave higher yields than the local varieties and had good grain quality. But, in general, they have proved to be susceptible to the attack of plant diseases. Thus, for instance, N.P. 125, A.O. 90, Kanpur 13 and C. 591 are susceptible to the rust disease; C.591, otherwise an outstandingly popular variety, is also susceptible to certain other plant diseases such as loose smut, bunt and ear-cockle. Even among these older wheats, however, there were some that showed a certain degree of disease resistance. N.P. 120 is highly resistant to

* The Institute was transferred to New Delhi after the irreparable damage caused to it during the Bihar earthquake in 1934.



Ear samples of the improved wheat N. P. 710 suitable for plains

yellow rust (also known as stripe rust) and moderately so to the other two rusts (black or stem rust and brown or leaf rust) in the adult stage. N.P. 52, N.P. 165 and Niphad-4 are partially resistant to the three rusts in the adult stage. N.P. 120 and N.P. 165 are resistant to loose smut.

Rust resistant wheats

With the help of funds provided by the Indian Council of Agricultural Research, systematically planned work on the development of rust resistant wheats was started in 1935 at Simla and, later on, in Madhya Pradesh and Bombay. The Simla centre was set up as a sub-station of the Indian Agricultural Research Institute, while work in Bombay and Madhya Pradesh was taken up at the experiment stations of the State Governments.

In Peninsular India, it is only the black rust that is a menace to the wheat crop, while in North India, which has the largest wheat area, all the three rusts prevail and can cause enormous losses in epidemic years. Breeding rust-resistant varieties of wheat for North India is, therefore, much more difficult and complicated than for Peninsular India and indeed for most other wheat-growing areas of the world where normally only one rust is a serious menace.

At the Indian Agricultural Research Institute, a new series of improved wheat varieties have been developed during the last decade. An outstanding general feature of these wheats is their tolerance of rust attack. Moreover, some of them, notably N.P. 710, N.P. 718, N.P. 761 and N.P. 770 are highly resistant to the loose smut disease. N.P. 710 has shown adaptability to a wide range of conditions and the quality of its grains is very good. N.P. 718 and N.P. 761 are relatively early in maturity; N.P. 718 is particularly suited to Delhi State and Rajasthan and N.P. 761 to Bihar and Orissa. For the hills, at higher altitudes, N.P. 770 is a very good wheat and it gives a particularly impressive performance if sown a little late in the season (end of October or early November). It is bearded and has bold, attractive grains.

Besides these, some strains have been developed which possess a high degree of resistance to each rust. Two such varieties are N.P. 789 and N.P. 790 which are immune to attack by all the races of black rust now prevalent in India. N.P. 783 and N.P. 784 are highly resistant to brown rust and N.P. 785 and N.P. 786 to yellow rust. Crosses were made also with a view to developing varieties that combine resistance to all the three rusts. Among the first fruits of this work is N.P. 809, which has done very well in the hills. This variety possesses an appreciable degree of resistance to all the three rusts in the adult stage, besides being agronomically superior. Two other varieties, N.P. 803 and N.P. 807 are under observation in regional trials with regard to their performance in the hills.

The rust resistant wheats developed in Madhya Pradesh include Hy. 65-4, Hy. 278, Hy. 277-1, Hy.172-2, Hy. 11-6, Hy. 11-1, Hy. 11-8 and Hy. 12. In Bombay State, hybridization between older wheats like Niphad-4 and a rust-resistant Kenya wheat has resulted in the production of several new strains that are outstanding for their resistance to stem rust. These strains which belong to the bread wheat group have been named as Kenphad 21, 25, 28, and 32. Work is under way to develop suitable rust-resistant strains also of the *durum* group as a great portion of the wheat area in the Bombay State is under *durum* varieties.

Among the wheat varieties recently developed in the

A general view of wheat crop at the Indian Agricultural Research Institute

Improved varieties of oats undergoing trial at Pusa

Punjab, C. 217 is reported to be suitable for cultivation under *barani* conditions in the Punjab, C.250 for humid regions such as Gurdaspur and C. 281 for the Hariana tract. C.253 is recommended by the State Department of Agriculture for cultivation in the Kangra valley and is reported to be resistant to yellow rust.

In 1949 work on the wheat rust problem was intesified and extended to cover the needs of different parts of the country, under the Co-ordinated Wheat Rust Control Scheme financed by the Indian Council of Agricultural Research. The central part of the scheme is executed at the Indian Agricultural Research Institute, New Delhi, and its three sub-stations at Simla, Pusa and Indore; work at another centre, Wellington, in the Nilgiri Hills, is also being started. This central portion of the scheme has now been taken over by the Government of India.

Work on the baking and *chapatti*-making qualities of wheats was undertaken at Lyallpur (now in Pakistan) some years ago under an Indian Council of Agricultural Research scheme. The Council has recently approved of a scheme under which the Indian Agricultural Research Institute will study the nutritive value of Indian wheats, with special reference to the breeding programme just referred to.

Genetical studies

Genetical studies are intimately connected with the breeding of crop plants and, therefore, work has been done in this line too. At the Indian Agricultural Research Institute, crosses were made among different varieties and species of wheat and also between wheat and related plants such as rye and the grass, *Aegilops*. While studying the genetics of such crosses, the possibility of utilizing them for the development of varieties resistant to diseases, drought, etc. has also been kept in view. Genetical work that has been carried out in the Bombay State included studies on the inheritance of a number of characters such as glume colour, glume hairiness, awn colour, grain colour and length of the vegetative period. These studies also threw some light on the origin of a variety, Kala-Khapli-568. Indications were that Kala-Khapli-568 had arisen as a natural cross between two varieties, Baxi and Khapli, belonging to two different groups of wheat.

Investigations on the vernalization of wheat included pre-sowing temperature treatment of the seeds as well as light treatment given to the plants after sowing. The effect of such treatment was to induce earlier flowering in some varieties. Vernalization is a useful tool in the hands of the breeder for inducing flowering in certain late foreign varieties and thereby making it possible to effect crosses between early maturing local varieties and the late ones. The results so far obtained, however, do not indicate that vernalization can have any large-scale application in general agriculture.

Some years ago, the Indian Council of Agricultural Research, set up a body known as the Wheat Nomenclature Committee to clear up the confusion caused by different workers using different terms to describe the same observations. This Committee prepared standard schedules for description of the characters of the wheat crop. Descriptions of a number of improved wheats, in accordance with these schedules, have been published.

Studies conducted at the Indian Agricultural Research Institute on the effect of natural selection

in mixtures of different species and of different varieties of wheat have indicated that competition in species mixtures is much more dynamic than in the mixtures of varieties. Consequently, certain species in a species mixture are eliminated much faster than some varieties in a varietal mixture. Among the factors responsible for survival in such a competition, the number of ears per plant and the number of grains per ear seem to be important.

Consideration of experimental work on the methods and practices of cultivation, application of manures, fertilisers, etc. to the wheat crop, indicates that we are yet a long way from the stage when we may expect to have manurial schedules and specific recommendations for cultural practices for the different soil types in a given arable area. There appears to be great scope for laying out complex experiments to provide essential data on the best mode of application of manures and fertilisers, and irrigation water in relation to particular strains of wheat, keeping in view the factors such as sowing date, seed-rate, etc.

Considering that our wheat-growing season is so short relatively to that obtaining in most of the major wheat-growing countries of the world, the yields per acre obtained in some of our good irrigated wheat areas is quite satisfactory, but it is capable of further improvement by the application of scientific methods. And in the areas where present production is poor, there is ample scope for increasing yields.

Barley

Barley is quite an important cereal in Northern India, especially in Uttar Pradesh. It can be grown on soils unsuitable for wheat, and generally matures earlier. In the hills barely is specially important and is grown even at considerable altitudes.

Barley types

As with other crops in India, attention was first paid to the collection of barley types and their study with a view to isolating the superior ones among them. Such a study was undertaken at the Agricultural Research Institute at Pusa (Bihar) and later continued at the same place as part of the work of the Botanical Sub-station of the Institute. Twenty-four types of barley were isolated and described with special reference to morphological and agronomical characters. Five of them were two-rowed barleys and the other six-rowed ones. One of the six -rowed barleys, N.P.21, has become established as a high-yielding barley suitable for eastern Uttar Pradesh and Bihar. Another variety N.P. 13 has done exceedingly well in Delhi and the surrounding areas, yields up to 56 maunds per acre having been recorded.

In the Punjab in addition to the older varieties, Type 4 and Type 5, a green fodder barley, C. 144, has been developed by means of hybridization. It is a smooth-awned type with relatively lesser requirements of water and can thrive on alkali lands. Barley C. 155, another variety produced by hybridization in the Punjab, is suitable for pearling and powder products. It is also reported to be suitable for malting and brewing. In Uttar Pradesh, C.251 has become the standard variety and is well-known for its high quality.

Inheritance of characters

Studies on the inheritance of various characters were also conducted in barley. The following charcters were found to depend on a single factor difference: (1) degree of awning, (2) narrow broad glumes, (3) purple colour in the pericarp and in the aleurone layer and (4) purple colour in the auricles. The fertility of the lateral florets seemed to be determined by one factor in one cross and by more than one factor in certain other crosses. Studies were also conducted on the hooded condition, hulled seed, etc. There were indications that the development of mechanical tissues in the stem was controlled by genetic factors. A study of the inheritance of the reaction to rust in relation to certain epidermal characters showed that the two, namely reaction to rust and epidermal characters, were inherited independently of one another.

Oats

In India, oats have relatively little importance as compared to several other cereals. They are mainly grown around dairies and cantonments, where they are much valued as fodder.

The Indian oats belong to a species (*Avena sterileis* var. *culta*) different from the one commonly cultivated in Europe and America. Two improved types, N.P. 1 and N.P. 2, were selected from the mixed country crop at the Indian Agricultural Research Institute. These two types are superior in yielding ability and resistant to drought, but not very good in grain quality. A number of interspecific crosses were successfully made in order to combine the desirable qualities of these varieties with those of certain European types, which possess good grain characters, but are rather late for Indian conditions.

The study of the genetics of a number of characters has also been carried out.

Millets

by

M. A. Sankara Iyer

Bajra hybrid (X 1) and parents

THE term "Millets" is a group name for a number of cereal crops grown primarily for their grain. It comprises plants belonging to different genera and species, with widely varying habits and characters.

The more common millets cultivated in India are *juar* (*Sorghum* sp.), *bajra* (*Pennisetum typhoides*, Stapf and Hubbard), *ragi* (*Eleusine coracana*, Gaertn.), *korra* or *kangni* (*Setaria italica*, Beauv.), *koden* (*Paspalum scrobiculatum*, L.), *kutki* (*Panicum miliare* Lam.), *chena* (*Panicum miliaceum*, L.) and *sanwak* (*Echinochloa frumentacea*, Link. = *Panicum frumentacea* Roxb). Besides, many other allied species, whose grains are used as food, are also reported to be grown to a limited extent or occur wild near hilly regions. They are *Setaria glauca*, Beauv., *S. verticillata*, Beauv., *Panicum colonum*, L., *P. crusgalli*, L. and *P. flavidum*, Retz.

Most of the millets are grown in almost all the States in India. They are considered to have been cultivated and used as bread grains from pre-historic times. Some believe that they are the first cultivated crops. *Juar* is reported to have been grown in Assyria as early as 700 B.C. Millets were superseded by wheat, rye, rice, maize and potato in Western Europe during 19th century. Their straws also are a valuable cattle fodder.

Millets are annual warm weather grasses. They are grown under conditions where other crops do not thrive and in regions of low rainfall, the average annual precipitation ranging from 20-50 inches. Most of the millets are of short duration, three to four months from seed to seed. Their nutrient requirements are low but they respond well to irrigation and manuring. Some of the millets, particularly *juar*, *bajra* and *ragi*, are also grown as irrigated crops in well manured soils. But they are mostly grown on dry lands with the help of rain alone.

In India, they are generally grown as mixed crops, the other crops grown with them being one of the pulses. They are grown in India on about 80 million acres annually and their production is estimated to be about 12 million tons.

Juar (Sorghum sp.)

Juar is the most important of the millets in respect of area and production, as well as size of plant and grain. It is grown annually on about 40 million acres and the production of grain is estimated to be about six million tons. It commands the largest area in Bombay State where it is grown on more than 10 million acres and in the adjoining Hyderabad State, where it is grown on

Bulk crop of cholam Co. 1 (juar) crop

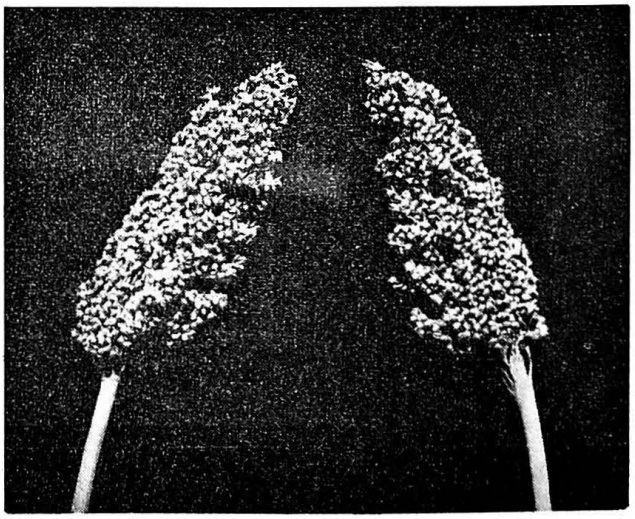
about nine million acres. In Madras* and Madhya Pradesh, it is grown on about five million acres. The plants range in height from less than 2 feet to more than 20 feet. The ear-heads vary from a hard cricket ball-like earhead to a long, loose, broom-like panicle. The commonest grain colour is white but other colours such as yellow, red and various shades of brown also occur. There are two main types with regard to the stem character, the pithy or dry stem and the juicy stem. The latter is mostly grown in areas of very low rainfall like the Deccan, and hence is an adaptation for drought resistance. The stalks of the juicy stem types are more relished by cattle. The variation in duration among different types is from three to six months.

Some work on the botanical aspect of *juar* has been done at the agricultural stations in Bombay and Madras States, side by side with the improvement of their economic aspect. The inheritance of most of the morphological characters had been studied at the Millet Breeding Station, Coimbatore (Madras).

The work at the agricultural stations in different States focussed more on the economic aspect, mainly the evolution of improved varieties to give more yield of grain and superior straw. Forty-two strains have been evolved at different agricultural research stations. Besides, these numerous types having superior economic characters are in various stages of trial in the States where *juar* is an important crop. Though numerous foreign varieties, chiefly from Africa, America and China, have been obtained and grown, none of them has replaced any of the local varieties. Synthetic derivatives for resistance to the root parasite, *Striga*, are in advanced stages of trial in Bombay and Madras States.

The crop is subject to a few insect pests and fungus diseases also, the more important of which are the seedling stem borer, a maggot of a fly, *Atherigona indica*, and the ear-head bug, *Calocoris angustatus*, among the former, and the grain smut caused by *Sphacelotheca sorghi* among the latter. The fly maggot destroys the seedlings in the early stages particularly under irrigated conditions. The ear-head bug does considerable injury to the grain in its early stages of development. Dusting or spraying with B.H.C. insectidal preparations soon after flowering has been found to be effective in destroying the bugs. The grain smut has been found to be prevented by treating the seed before sowing with sulphur

Sorghum (juar) Ujjain-8



* Madras State prior to the formation of Andhra State

or some proprietory fungicidal dusts. Some work on the agronomic aspect of the crop has also been done in some of the agricultural stations.

Bajra (Pennisetum typhoides)

Bajra is the second important millet in India. It is grown on about 24 million acres and the estimated production of grain is about 2·5 million tons. The largest area of this crop is in Bombay State, about six million acres. Almost an equal area is in Rajasthan. The duration of the crop varies from about two and a half months to five months in different varieties. The shorter duration types are generally preferred. Breeding of this millet was commenced in Poona in 1921 and about two years later at Coimbatore in Madras. Work on this crop has been in progress in the Punjab and Uttar Pradesh also, and has recently commenced in Saurashtra and Bihar. Studies on the botanical aspects of this millet have been carried out in Bombay and Madras. It differs from other millets in that it is protogynous, *i.e.*, the stigmas become fertile and receptive before the anthers mature and dehisce. So normally it is cross-pollinated. Hence improvement of this crop by isolation of pure line selections has been found to be not quite promising. Mass selection was found to be the better method.

In recent years, production of hybrid seed from selected parents has been in progress in Coimbatore. Two hybrid combinations have been found to excel local varieties in yield of grain in parts of Madras State, and the hybrid seeds are being produced on a bulk scale and distributed. Work on similar lines to exploit hybrid vigour, is in progress in Bombay also and one hybrid combination has been found to be promising. Improvement by hybridization, by exposure to X-ray and by colchicine treatment are in progress in the Punjab. Breeding of improved varieties is being done in Uttar Pradesh, Bihar and Saurashtra also. Earlier work on this crop has resulted in the isolation of eight strains by selection in Madras, four strains in Bombay, two in the Punjab and one in Uttar Pradesh.

Ragi (Eleusine coracana)

Ragi ranks third in importance among the millets in India. The total area under this crop is nearly 5·5 million acres, and the estimated production is nearly 1·75 million tons. More than half of the total area under this crop is in Madras and the adjoining Mysore State—about 1·5 million acres in each. The important variations observed are in ear-head shape and plant pigmentation. The seed coat is generally brown in colour; a few types with white grains also occur. The genetics of this millet has been studied in some detail at Coimbatore. Sixteen improved strains of *ragi* have been evolved in Madras State and two strains in Mysore, and these are being grown in different parts of these States. Breeding of this millet has been undertaken in recent years in Bombay, Bihar and Uttar Pradesh.

Other millets

The other millets, grouped under "Small Millets", are grown in India on about 11¼ million acres and their estimated production is about 1·75 million tons. The grains of these millets are enclosed in persistent husks, which could be separated only by mechanical means. When the husks are removed the grains are more or less white or creamy in colour. They are mostly grown in regions of low soil fertility and rainfall. The most important among these millets is *korra* (*Setaria italica*, Beauv.). It is grown in Madras State on about 1·5 million acres. Seven improved strains of this millet have been evolved and are being multiplied and distributed. Some work on the genetics of *korra* has also been done. Isolation of improved strains resistant to leaf-rust, a serious disease of this crop plant, has been receiving attention in recent years. The other small millets which are cultivated to some extent are *Paspalum scrobiculatum*, L., *Panicum miliare*, Lam., *Panicum miliaceum* L., and *Echinocloa frumentacea* Roxb. The study of these millets has also been in progress in Madras State. Two high-yielding strains of *Paspalum* have been evolved and are being distributed to the cultivators. Types of the other millets are being maintained at the Millet Breeding Station, Coimbatore.

Maize

by

S. M. Sikka

A field of high yielding N.C. 27 hybrid

AMONG the cereal crops grown in India, maize is cultivated over an area of 8·5 million acres and gives an annual production of over 2·5 million tons. This cereal occupies the largest area in Uttar Pradesh, Bihar and Rajasthan, but is also grown on quite an extensive scale in several other States. Maize is of special importance in the hilly and sub-montane regions of the country, where it forms the staple diet of the people, particularly in the winter months. In the northern parts of the country, it is also extensively grown as a fodder crop. The "flint" variety, among which the red-grained biotype predominates, forms the bulk of the maize crop grown in this country.

The first concrete step towards the improvement of this crop was taken only in 1945 when a scheme was launched for synthesising improved maize hybrids, first at Lyallpur and then at Jullundur. At the Indian Agricultural Research Institute, New Delhi, and in several other States breeding work was taken up on this crop.

The Punjab Scheme has made good headway in so far as over 15,000 plants derived from 300 commercial varieties have been hand pollinated and quite a few lines, some of which have been selfed for eight successive generations, have attained apparent homozygosity. The work of this scheme has shown that while most of the lines do not attain reasonable purity for such characters as yield, height, size of grain, etc. even after six to seven successive generations of selfing, a few do so after only three to four successive selfings. The advantage offered by the latter lines has been fully exploited in this Scheme for making "top" and "single" crosses at a much earlier stage than it would have been possible normally. So far over 500 "top" and 1000 "single" crosses have been made and tested and quite a few of these have out-yielded the best local varieties, kept as standards, by significant mar-

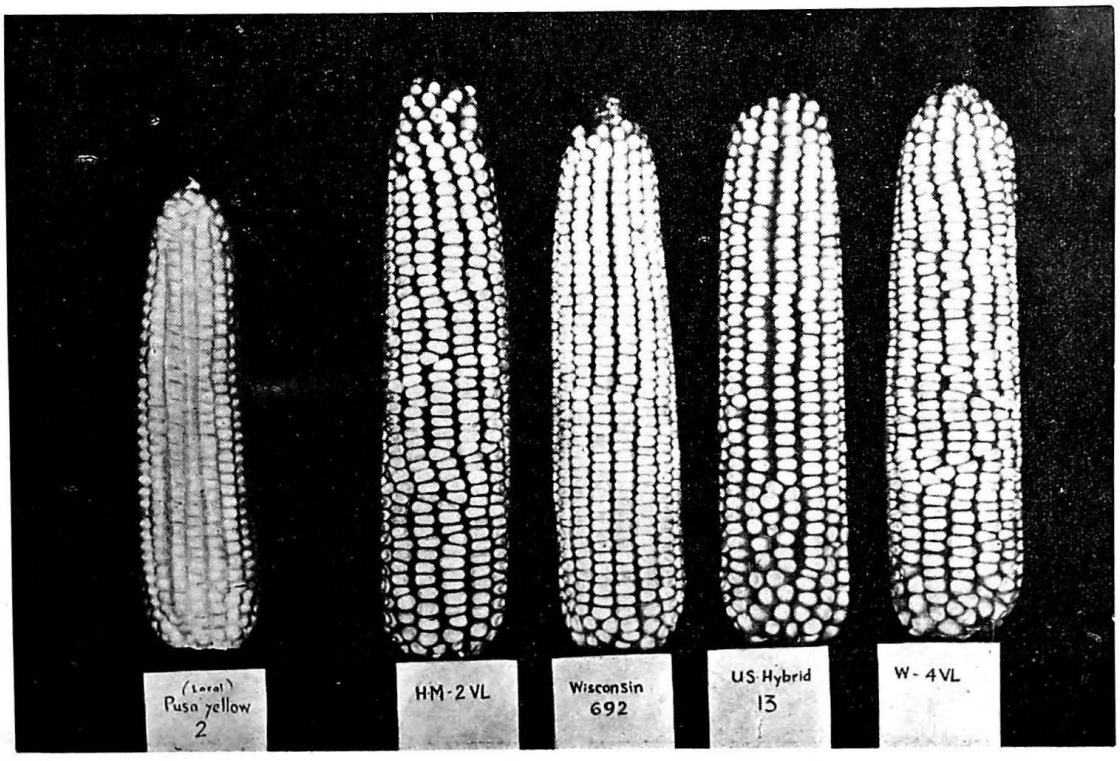
gins, the excess in yield in some cases ranging over 100 per cent over the local varieties.

While the schemes in the Punjab, PEPSU, Uttar Pradesh, Rajasthan, West Bengal, Bihar and Hyderabad are concentrating on synthesis of high-yield hybrids, the emphasis in the Scheme operating at the Indian Agricultural Research Institute, New Delhi, is mainly on problems of fundamental importance. The most important aspect on which work is being carried out in this scheme is to find out short-cut methods by which inbred lines could be produced in one step instead of 7-8 years required under the commonly used selfing method. Still another problem of far-reaching value being tackled is connected with the study of methods by which the hybrid vigour usually exhibited by the F_1 plants could be conserved for two or more generations so as to obviate the necessity of producing hybrid seed of promising crosses every year.

Trial of foreign hybrids

As "hybrid corn" technique is a long range process it was thought advisable to import ready made double crosses of "dent" corn from the U.S.A., Australia and Canada and to test them in this country with a view to finding out if any of them would suit the Indian conditions. The Indian Agricultural Research Institute, New Delhi, has arranged a co-ordinated trial of 36 foreign hybrides in almost all the important maize-growing States. These trials have been carried out both in hilly tracts and plains for the last three years and the indications are that some of them can be successfully grown in this country, particularly in the hilly tracts. The results have been generally favourable to American and Australian hybrids among which U.S.13, Dixie 11, Dixie 22, Dixie 33 and N.C. 27 have recorded better yield performance than the local varieties tested against them.

Mature cobs of open pollinated flint and hybrid dent types. From left to right Pusa Yellow 2 (Flint, Indian open pollinated variety), H.M.-2 V L, Wisconsin 629, U.S. 13, and W-4 V L dent hybrids



Hybrid seed on a commercial scale

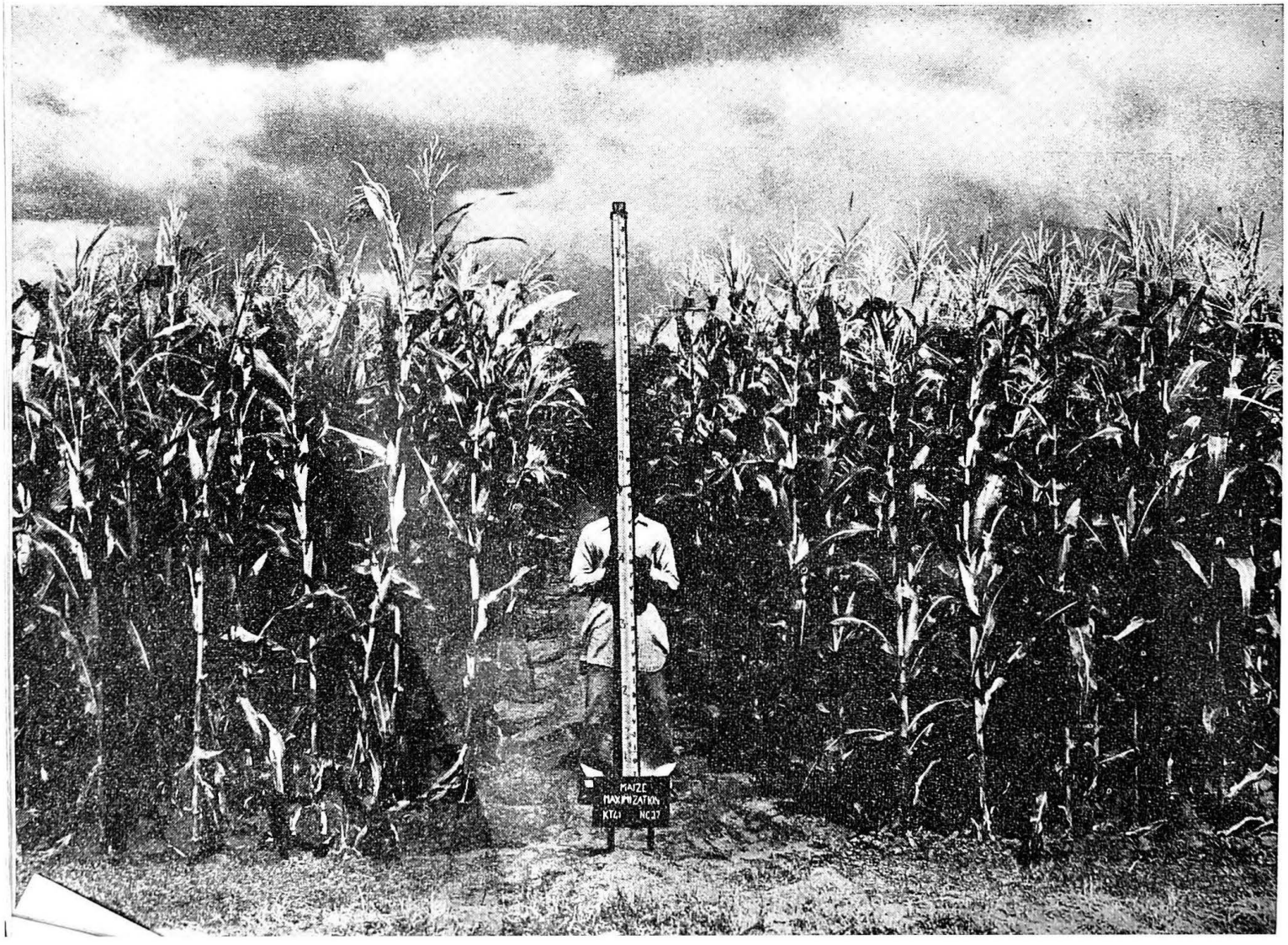
Steps have been initiated by which production of hybrid maize seed on a commercial scale could be arranged on modern lines.

A pilot scheme has been in operation at Almora in Uttar Pradesh for producing annually 100 maunds seed of U.S. 13 which has given good yield performance in some parts of the country.

Development of sweet corn

A scheme for developing cultivation of sweet corn in the hilly tract of the Punjab is in progress. This scheme is functioning in the Kulu valley of the Kangra District and work of testing imported varieties of sweet corn as well as finding out the agronomic treatments, which will enable such corn to be cultivated successfully, is being carried on.

Maize crop of Kanpur Type 41(left) and a double cross American hybrid, N.C. 27 (right) before harvest



An arhar plant of improved variety

Collection of new material and its study ; selection of individual plants for isolation of pure lines suited to different tracts with regard to maturity and other local conditions; preliminary yield tests of the promising selections ; final yield trials on field scale at research farms and on farmers' fields ; agronomic trials to discover suitable seed rates, spacing, crop mixtures, time of sowing and rotations; study of quality factors ; multiplication and distribution of seed of the improved types evolved as a result of the work conducted under the schemes. Some of the schemes have been satisfactorily completed.

Recent improved varieties of pulses

The varieties bred under the schemes mentioned above and recommended as superior to the local varieties as a result of district trials, are mentioned below with respect to particular crops.

Gram : In Bihar, B.R. 17, B.R. 65 and B.R. 77 have given 5-7 per cent higher yields as compared to the standard type S. 4 in south Bihar.

In Bombay, nine strains have been finally selected as promising.

In Hydrabad, strain 63-8-12-41 has given, on an average, about 11 per cent higher yield than the local varieties in the district trials during the last three years.

In Madhya Bharat, strains Gwalior 2 and Bijaypur 3 have been developed for the northern region and Chanderi 24 and Bhind 19 for the southern region. Bhilsa 2 and Bhilsa Green are considered quality-grams for the southern region.

In Madras, Co. 1 evolved at Coimbatore is recommended for the districts of Coimbatore and Rayalaseema.

In Mysore, three selections, yielding appreciably higher than the local varieties, are under trial.

In Uttar Pradesh, Type 87 has covered considerable areas in a majority of the districts and is rapidly becoming popular because of its vigorous growth, high grain yields and very superior grain size and quality as well as adaptability to a wide range of growth conditions.

Arhar: In Bihar three early maturing strains, B.R. 13, B.R. 59 and B.R. 172, which are ready for harvest by the end of October have been recommended. Medium maturing strains B.R. 60, B.R. 65 and B.R. 71, and late maturing strains B.R. 15, 7S, B.R. 10 and B.R. 17 (the last two having an erect habit of growth), have been finally selected as superior strains. In Bombay, strains F.18 and F. 62 have been finally selected for trials in the districts on account of high yield and wilt resistance. In Hyderabad, four of the improved strains are under district trials. In Madras, strain SA 1, selected at Salem sub-station, has been recommended for the central and southern districts of the State.

In Uttar Pradesh, Type 17 which gives high yield, and possesses the qualities of palatability and moderate wilt resistance, has been under general distribution on account of better yields than the local varieties. Some better yielding types are under final tests. Type 1 has been released as a good early variety maturing by the end of November.

Urd: In Bihar, types B.R. 10, B.R. 11, B.R. 68 and S.T. 8 giving 12-27 per cent higher yields than local varieties have been recommended for the southern districts.

In Madras, type VZM 1, evolved at Vizianagaram, is recommended for the northern coastal districts (now in the Andhra State).

In Orissa, S. 1601 has consistently yielded considerably higher than the local varieties in trials since 1947-48 and is recommended for multiplication.

In Uttar Pradesh, Type 9 (early variety) and Type 27 (late variety) are under distribution.

Mung: In Bihar, B.R. strains 1-6 and S.T. 7 have been finally selected for the southern districts. B.R.I. has green seed and is medium in maturity. B.R. 2, B.R. 3, and B.R. 4 have black seed and are early and the remaining three have yellow seed and are late in maturity. The increase in yield over the local Type S.T.I. has varied, on an average, from 3-14 per cent.

In Bombay, selections 781 and 1/49 from the early China *mung* variety are being finally tested in the districts.

In Madhya Bharat, the early strain Krishna 11 and the late strain Khachrod 5 have been found suitable for the northern region and late strain Bhilsa Green 16 for the souther region.

In Madras, Co. 1 evolved at Coimbatore has proved suitable as a dry land crop in the southern districts.

Pulses

by

T. R. Mehta

Gram of improved type

ABOUT one-seventh of the cultivated area of the country annually grows the important group of crops commonly known as pulses. These crops figure prominently in the crop rotations and crop mixtures practised by the farmers of India. Being leguminous crops they help in the maintenance of soil fertility and, being rich in proteins, they supply a major share of the protein requirements of the predominantly vegetarian population of the country. Some of the pulses serve as excellent forage and grain concentrates in the feed of the large cattle population of the country.

The major pulse crops of India and the percentage of area and production of each are given below.

Major pulse crops of India

Botanical names	English or vernacular names	Percentage of total	
		Area	Production
Cicer arietinum	Gram or Bengal gram (*chana*)	37.0	44.4
Cajanus cajan	Pigeon pea, red gram (*arhar* or *tur*)	13.0	18.8
Phaseolus mungo	Black gram (*mash urd* or *kalai*)	6.6	3.6
Phaseolus aureus	Green gram (*mung* or *mug*)	5.6	3.6
Ervum lens	Lentil (*masur*)	2.4	2.3
Doliches biflorus	Horsegram (*kulthi* or *gahat*)	5.7	2.2
Pisum spp.	Peas (*matar* or *vatana*)	5.0	7.2
Lathyrus sativus	*Lakh* or *Khesari*	3.8	2.8
Phaseolus aconitifolius	*Moth* or *matki*	0.9	0.5
	Other pulses	20.0	16.0

During the thirties, some improved varieties of different pulse crops were released by the various Departments of Agriculture for general distribution among the growers. Pigeon pea varieties N.P. 15, N.P. 16, N.P. 24, N.P. 51, N.P. 64 and N.P. 80 (the last being highly wilt resistant) were released by the Indian Agricultural Research Institute, Pusa ; types E.B. 3 and E.B. 38 were released in Madhya Pradesh, and types 23, 24, 51 and 66 were released in Uttar Pradesh. E.B. 28 of Madhya Pradesh and S. 4 of Bihar established some reputation as high yielding grams in the respective States.

The Indian Council of Agricultural Research set up a special sub-committee in 1940 to consider the proposals for research on the improvements of pulse crops on a co-ordinated basis in the important pulse growing States of India.

The general programme of work was somewhat on the following lines :

In Orissa, S. 150 has consistently yielded significantly more than the local variety and is being released for general cultivation.

In Uttar Pradesh, *mung* Type-1 has figured prominently as a new catch crop in several districts as a short duration legume to replace monsoon fallows, and to serve as a dual purpose green manure and grain crop.

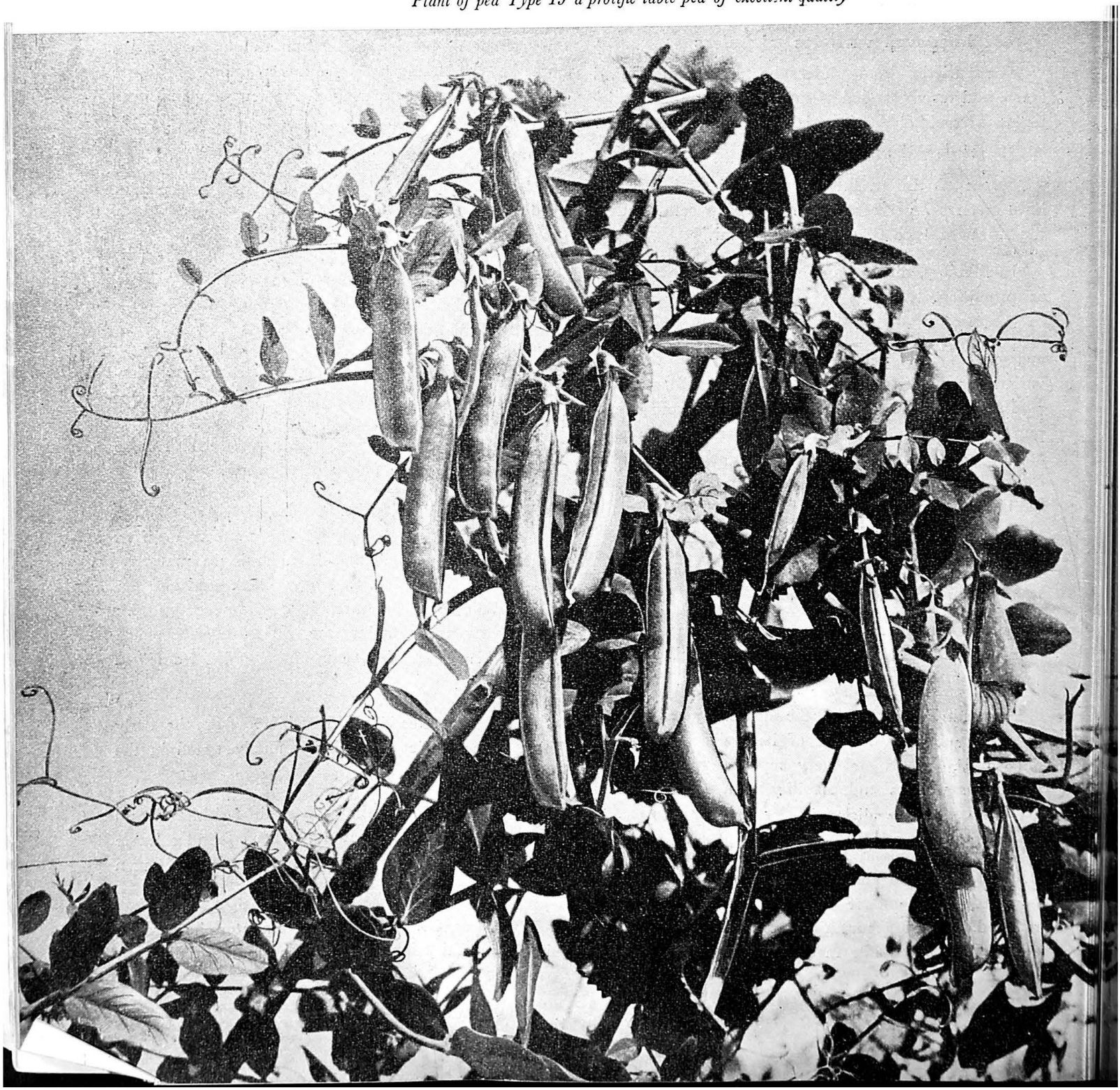
Pea: In Bihar, B.R. 2, B.R. 12 and B.R. 118 among white flowered strains, and B.R. 178 among the purple flowered strains, giving 11-26 per cent higher yield than the local varieties, have been recommended.

In Uttar Pradesh, the remarkable yielding ability and quality of white pea Type 163 have made it a hot favourite in most districts of the State. At places, it has given to the growers double the money return compared to the local peas, on account of better yields (50-60 per cent higher) and quality (securing 30-50 per cent better price). Type 19 is recommended as a high quality table pea of good yield.

Scheme on gram wilt in the Punjab

A series of experiments were carried out on gram wilt in the Punjab to study the causes of gram wilt and devise remedial measures against it. A large amount of data was collected; these gave some interesting information on agronomic factors which might play an important part in reducing the losses from grams wilt.

Plant of pea Type 19 a prolific table pea of excellent quality



Oil Seeds

by

C. R. Seshadhri

INDIA is a vast sub-continent with a variety of soils and climate, and grows a number of oil-seed crops. The main crops dealt with here are groundnut, rape and mustard, coconut, linseed, sesamum and castor. Niger and safflower are considered of minor importance.

The groundnut is believed to be of Brazilian origin and is supposed to have been introduced into India in the early half of the 16th century. It has now come to occupy over 10 million acres representing 41 per cent of the area under oilseeds in India and 40 per cent of the world production of groundnuts. Madras, Hyderabad and Bombay are the principal groundnut producing States. It is cultivated to some extent in Madhya Pradesh, the Punjab and Uttar Pradesh.

Research work

With the largest area of about four million acres under groundnut every year, Madras leads the other States in India in groundnut improvement work. Madras has produced four improved strains of groundnut, TMV. 1 to TMV. 4 by selection and these have been extensively tested and found to be superior to the local varieties in regard to yield, oil content, etc. The increase in yield is well over 25 per cent. Some of these strains are drought resistant and comparatively more resistant than the local varieties to the leaf miner pest.

The States of Bombay and Hyderabad each has an area of about 2½ million acres under groundnut annually. In the Bombay State, three improved strains of the bunch type, *viz.*, Spanish Peanut No. 5, Spanish Improved and Kopargaon 3, and two improved strains of the spreading type, *viz.*, Pondicherry 8 and Kopargaon No. 1, have been evolved. The first two strains are of the bunch type and are being multiplied and distributed on a large scale to growers.

In Uttar Pradesh, groundnut is grown annually in an area of 1½ lakh of acres. Here, three bunch strains, *viz.*, types 18, 23 and 24 were first evolved and distributed among growers. These were later replaced by the spreading strain Type 25 which was more popular with the cultivators.

The State of Mysore has an area of about 2½ lakh acres under groundnut. One spreading (H.G. 7) and 10 bunch types H.G. Nos. 1-6 and 8-11 representing varying durations and features have been evolved by selection and hybridization.

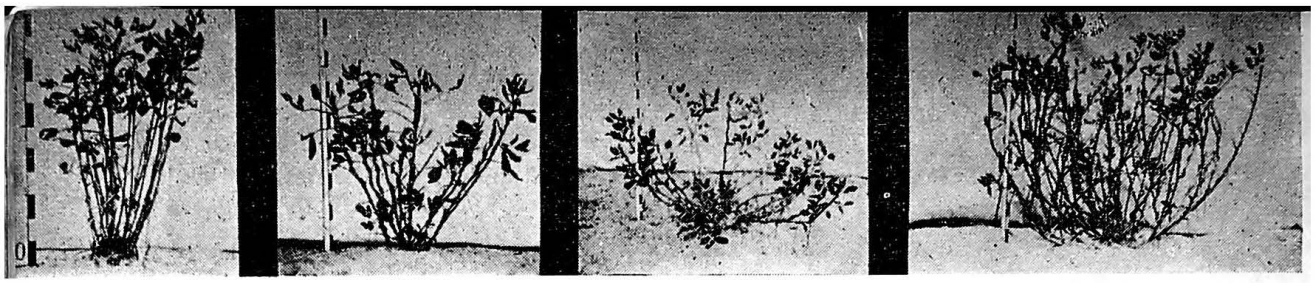
On the agronomic side investigations have shown that (*i*) a spacing of 6 in. and 9 in. either way for a seed rate of 100 lb. and 75 lb. of kernels per acre for the bunch and spreading types respectively are the optimum ; (*ii*) the proper time for harvest is when the crop is fully mature as is indicated by the yellowing of the leaves and the development of a dark colour inside the shell ; (*iii*) raising the groundnut crop as a mixture with cotton, castor, *Jowar* and redgram is more remunerative than raising it alone ; (*iv*) cereals after groundnut give much better yields than cereals following cereals ; (*v*) though groundnut responds to the application of potash and phosphoric acid, it shows sustained response to the application of cattle manure particularly in years of deficient rainfall ; and (*vi*) four to six ploughings, given as preparatory cultivation, ensure economic returns from the crop. In Mysore, the optimum spacing (12 in. × 9 in.) and an efficient rotation (groundnut-ragi) have been determined.

The most serious pest on groundnut is the 'surulpoochi' or the leaf miner (*Stomopteryx nertèria*). The pest is controlled to some extent by setting up light traps. In recent years, dusting with DDT 5 per cent twice and spraying with 0.1 per cent DDT were both found to be effective against the pest and economical as well. Spraying 3/4 per cent bordeaux mixture and dusting sulphur thrice at monthly intervals were both effective against the 'tikka' leaf spot disease. The fungicidal treatments also result in marked increase in yield of the crop.

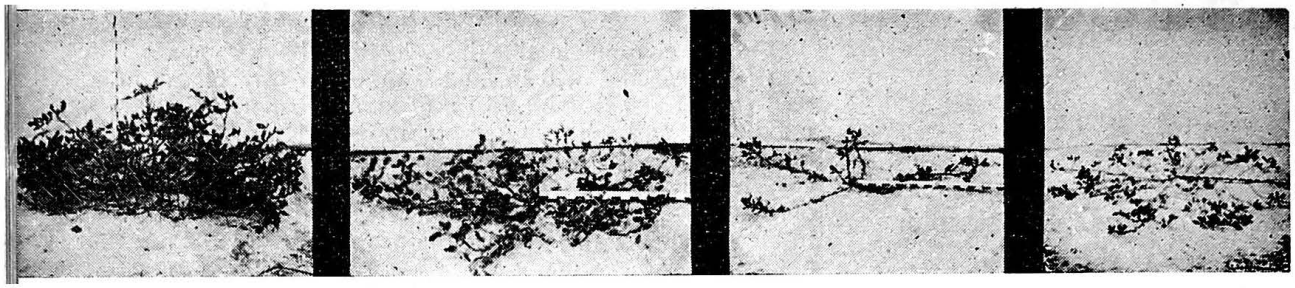
Rape and mustard

Next in the order of all-India importance to groundnut come rape and mustard. The area under rape and mustard is about 4½ million acres with an annual production of over 7½ lakh tons. The State of Uttar Pradesh accounts for nearly three-fourth of the area and the States of Bihar, the Punjab, Assam and West Bengal together make up over 1½ million acres. The crop is raised during the period October to March-April, mostly as a mixed crop with wheat and gram and in some places as a pure crop.

In Uttar Pradesh, three strains, *viz.*, Rai T-4, T. 11 and L. 16 have been found to be early types yielding better than the local varieties. For mixed croping with wheat, the strain Rai E.T. 3/2 has been found to be suitable. The Muzzafarnagar *sarson* (A.G.H.A.), a bold seeded late type, is suitable for the western tracts of Uttar Pradesh where the winter is prolonged. In West Bengal, two strains, *viz.*, Toria No. 7 and *Rai* No. 5, were evolved and seeds of these were distributed to cultivators in the districts. In Assam Type No. 8



Erect *Bunch* *Bunch spreading* *Vigorous bunch*



Vigorous spreading *Spreading* *Non-branching spreading* *Trailing*

Groundnuts — Progenies of a cross between a bunch spreading type showing the range of material for economic selection

was outstanding in yield, Type No. 25, closely following it Type No. 22 of red mustard, gave 50 to 64 per cent increased yields over other local types.

Sesamum

Sesamum occupies an area of 4 million acres giving an annual production of over 3½ lakh tons. The Uttar Pradesh is the largest producer of sesamum in India followed by the States of Madras, Hyderabad, Bombay, Madhya Pradesh and Bihar. Sesamum is in great demand for the oil is used mostly by the upper middle class in Madras, Mysore and certain parts of Hyderabad. The oilcake is valuable as a concentrate for milch cattle.

Madras has produced three improved strains of sesamum, *viz.*, TMV 1, TMV 2 and TMV 3. These have been extensively tested on field scale and found to give 20-50 per cent increased yields over local varieties. TMV 1 is suitable for rain fed and irrigated cropping and its duration is of about 85 days. The strain TMV 2 is suited for winter cropping and combines desirable characters such as short duration, high oil content, light coloured seed and 6-8 loculed capsules. The strain TMV 3 is suitable for being grown as an irrigated crop in summer. It has given 50 per cent increased yield over local varieties and has the additional quality of being more resistant to wilt disease and shoot-webber pests. Bombay State has evolved one strain, No. 85, giving higher yields, having high oil content and bold white seed. In the Madhya Pradesh strains No. 41, N. 128 and N. 8 have given higher yields than local varieties. Intensive inter-specific hybridization and cytological work have been in progress at the Indian Agricultural Research Institute with a view to evolving strains resistant to pests and diseases.

Linseed

The area under linseed in India is just 3½ million acres with an annual production of over 3½ lakh tons. About a third of the area is located in Madhya Pradesh, followed by Uttar Pradesh, Bihar and Hyderabad.

In Madhya Pradesh, two strains N. 3 and N. 55 were evolved by selection and these have recorded higher yields than the local varieties. But in years of severe rust incidence, the strains I.P. 135 and I.P. 328 have given increased yields over these two strains. The best yields were recorded by N. 3 in years when there was no rust disease. In Uttar Pradesh, out of six improved strains evolved by selection and breeding only T. 1193-2 and T. 477 are popular and being distributed. In Bihar State, one improved strain, *viz* Sabour 6 was first evolved. This was later crossed with rust resistant types like I.P. 12 and I.P. 121, and a brown seeded strain B.R. 1, with high oil content, and another strain B.R. 2 were produced. Economic forms have also been isolated in flax. Punjab has produced four improved strains, *viz.*, K. 1, K. 2, I.P. 37 and I.P. 10 which have given 50-125 per cent increased yields over local varieties in one year. Bombay has evolved two improved strains, *viz.*, *Malshiras* 10 and Sholapur 36. In West Bengal three improved strains P.H. 6, P.H. 52 and B. 58 had been

evolved by selection. In Assam three improved types were isolated from varieties grown in the Surma Valley and five promising types from a collection at the Jorhat farm. At the Indian Agricultural Research Institute, intensive work has been done on linseed. Types N.P. 12, 121 and 124 evolved at the Institute have been found suitable for being grown in Uttar Pradesh, Bihar, Bengal and Assam. These are heavy yielders and fairly resistant to rust. Breeding work for evolving dual purpose (oil and fibre) strains is in progress.

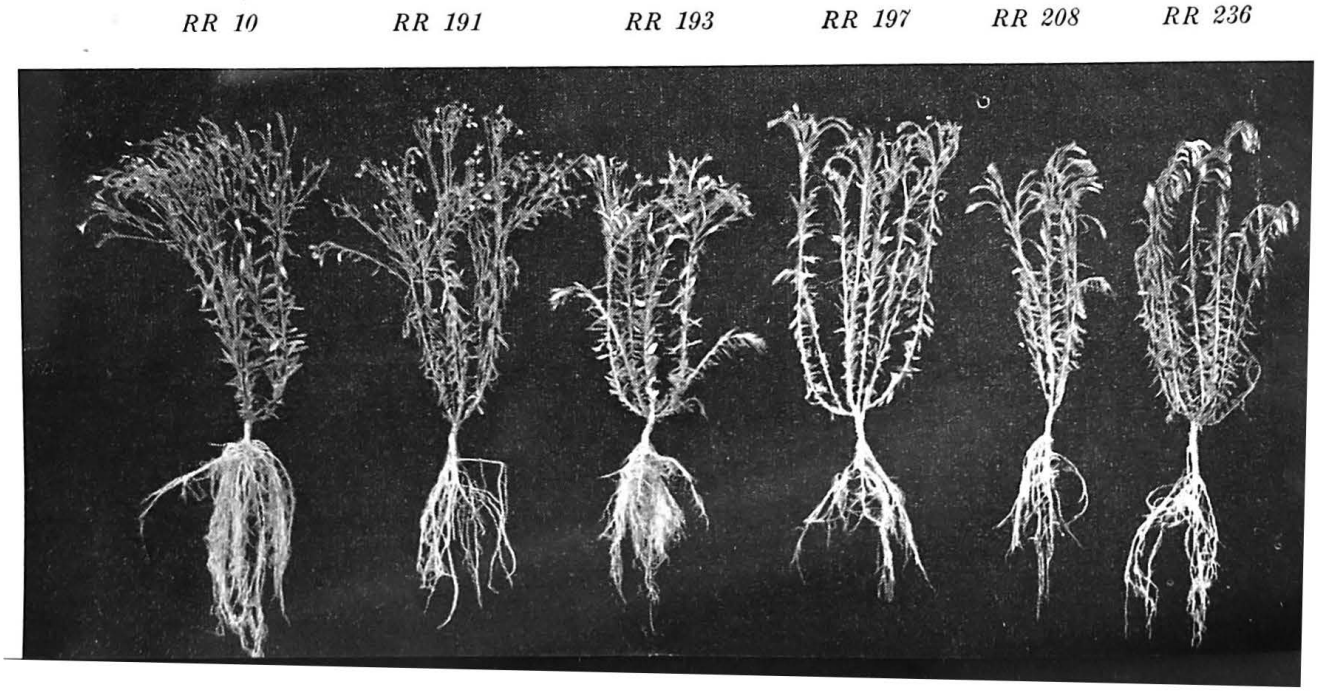
Trials conducted at Sabour farm have indicated that linseed responds to the application of nitrogenous and phosphatic manures. It has also been shown that extraction of linseed fibre is both practicable and profitable.

Castor

Castor comes next in the order of all-India importance, occupying an area of about 1½ million acres and an annual production of over 1¼ lakh tons. Over half of all-India acreage is located in Hyderabad State, the next in importance being the States of Madras and Bombay. This crop is cultivated mostly for the seed which yields the castor oil of commerce. The oil finds extensive use as a lubricant. It is also used for lighting, in medicine and in industry. The oil-cake is used as manure for sugarcane, vegetables, paddy and other crops. In States like Assam and Mysore, the leaves of the plant are fed to the *Eri* silk worm. Castor comes up well under varied conditions of soil and climate. It is raised mostly as a rain fed crop in the *kharif* season and is generally sown mixed with other crops except in Hyderabad and portions of Madras and Mysore, where it is raised as a pure crop.

In Madras State, three improved strains of castor, *viz.*, TMV. 1, TMV. 2, and TMV. 3 have been evolved as a result of extensive selection and hybridization work. A perennial high yielding strain named Co. 1 with a high oil content of 55 per cent has also been evolved by selection from the Annamalai perennial variety. The improved strains have given increased yields of 15-80 per cent over the local varieties and are shorter in duration by one to two months. They are also richer in oil than the local varieties. In Hyderabad State, four high yielding strains, *viz.*, H.C. 1, H.C. 2, H.C. 3, and H.C. 4 were evolved. Of these H.C. 1 was the best in yield and oil content. Three strains H.C. 5, H.C. 6 and H.C. 7 combining high yield and oil content and seed type similar to the local varieties were also evolved. The Hyderabad strains have also done well in States like the Punjab, Uttar Pradesh, Mysore and Rajasthan. Bombay State has produced one improved strain *viz.*, S. 20 giving

Rust resistant strain of linseed



higher yields and with higher oil contents than the local varieties. Madhya Pradesh has evolved two improved strains, E.B. 16 and E.B. 31, which were locally superior to the Hyderabad strains in yield. In Mysore State, two improved strains, L. 53 and L. 242, isolated from collections of strains and varieties from other States, have been recommended for cultivation as a pure crop in areas of deficit rainfall and three strains, L. 73, L. 74 and L. 77, as mixed crops in areas of medium rainfall.

Agronomic experiments have shown that a spacing of 3 ft. either way is the optimum and that the best yields are obtained when the heads are harvested at full maturity and dried immediately after harvest instead of curing them in stacks for some time.

Niger

India is the chief producer of niger seed in the world and has an area of roughly over 7 lakh of acres under the crop with an annual estimated production of about 60,000 tons. It is chiefly cultivated in Madhya Pradesh, the Deccan and north-east Madras. The oil is edible and is also used in making soaps, and for lubrication and lighting purposes. The oil cake is a rich concentrate for milch cattle and is rarely used as manure. The crop comes up well in lateritic and light loamy soils and is generally raised as mixture with pulses and other *kharif* crops from July-August to November-December.

In Bombay State, three selections, Poona, Roha and Sholapur have given 15-25 per cent increased yield over the local. At Kopragaon, two selections have given 30 per cent increased yield over the local. In Madhya Pradesh, one strain of niger, *viz.*, N. 5 was isolated as the best yielder.

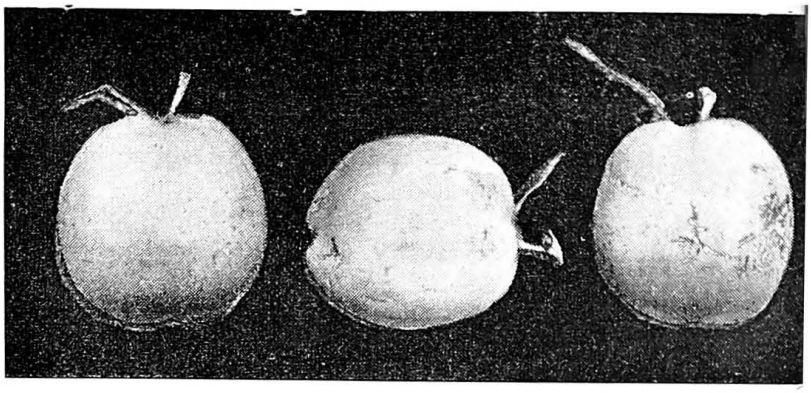
Safflower is largely cultivated in the States of Bombay, Madhya Pradesh, Hyderabad, Mysore and north-east Madras.

In Bombay State, the strain N. 630 gave 20 per cent increased yields over the local varieties. Among the Karnatak selections, Baihongal 1-6-3 and Gadag 2-10-3 have recorded 10-15 per cent increased yields over the local variety at Poona farm. Among the Deccan strains, Sangamner 2-3-2 and 2-10-1 have consistently given 25 per cent increased yields over the local. In Madhya Pradesh, one strain, No. 7 was isolated as the best yielder.

Coconut

by

C. M. John



Ideal seednuts — medium sized, with nearly round shape

THE coconut palm is chiefly cultivated for its nuts. The tender nut gives a very wholesome and refreshing drink, while the raw kernel of the more mature nut is widely used for culinary purposes. The dried kernel or copra when crushed, gives the coconut oil which is used for edible and industrial purposes. Hydrogenated vegetable fats, soaps, toilet articles and cosmetics are made out of coconut oil. The coconut oilcake or *poonac* is a valuable cattle feed. The coconut husk is processed into coir fibre. Ropes, door mats and mattings are made out of the coir yarn spun from the fibre. The unopened spathes, when tapped, give *neera* or fermented toddy. The *neera* can be processed into *gur* or sugar and fermented toddy into alcohol or vinegar according to needs. The trunk of the mature palm provides strong timber for house construction. The dry leaves are plaited and used for thatching houses. The dry petioles, husks, shell, etc. are extensively used as firewood and the ash thus obtained as manure. The culture and industry of the coconut is, therefore, intimately connected with the daily occupation and economy of the people of the tract where it is largely cultivated.

Acreage and production

India at present ranks second in world acreage and production of coconut. She accounts for 1·5 million acres of coconut out of a world acreage of 8·4 million acres and for production of 3,300 million nuts against the world production of 15,000 million nuts. The States of Travancore-Cochin, Madras, Mysore and Andhra account for the bulk of the area and production. There are also appreciable areas under coconut in Orissa, Bombay and Bengal and in the Andaman and Nicobar Islands, and the Laccadive group of islands off the Malabar Coast.

Coconut industry

Prior to the First World War, India had been exporting appreciable quantities of copra and oil to foreign markets. The development of coconut plantations on an organised scale in the Pacific Islands and other tropical countries and the fillip the First World War had given to the vegetable oil, soap and toilet industries in India, resulted in increased demand and the consequent dumping of copra and oil into our country. The result was that the Indian producer, with his small holdings, could not compete effectively with foreign countries. Prices fell considerably. The coconut industry of the West Coast in particular was affected most. The Government of India caused an all-India enquiry to be made in 1935, through the Indian Council of Agricultural Research, on the then position of the coconut industry in the country. The enquiry resulted, *inter alia*, in the initiation of two research schemes under the auspices of the Council, one in 1937 in Travancore for the control of the "Root and Leaf Diseases of Coconut" which accounted for considerable reduction in yield, and the other in 1938 in Madras State for solving certain problems of fundamental and practical importance connected with the economic production of coconut. These two research schemes, which had already produced some useful results, were taken over by the Indian Central Coconut Committee in January 1946. The Travancore Scheme was subsequently amalgamated with the work of the Central Coconut Research Station, Kayangulam

which was set up by the Indian Central Coconut Committee for the investigation of pests and diseases of coconut, while the Madras Scheme was worked to completion by the State Department of Agriculture at their Coconut Research Station, Nileshwar, in the South Kanara District.

Progress of research

The important agricultural research stations which carried out investigations on the coconut were the ones at Kumta in North Kanara, Babur in Mysore, Puri in Orissa, Kasaragod and Nileshwar in South Kanara of Madras State, Vytilla in Cochin and Alleppey in Travancore. These research stations dealt with some cultural and manurial aspects of coconut and trial of varieties, and some of them were closed down after some time. Sustained interest was in evidence only at the Coconut Research Stations of the Madras Government. The work carried out under the auspices of the Indian Council of Agricultural Research, though not comprehensive, had brought out some useful results of practical importance. The criteria for the selection of seedlings which would grow into high-yielding palms and for determining the stage of maturity of nut for the production of copra and fibre of good quality have been established. Reliable information on the advantages of growing green manure crops, inter-cultivation and manuring also became available as a result of the work done at Kasaragod and Nileshwar.

The investigations carried out under the scheme of research on the "Root and Leaf Diseases" of the coconut palm in Travancore have shown that systematic inter cultivation and manuring and periodical spraying of trees with a copper fungicide would reduce the virulence of the leaf disease.

The Indian Central Coconut Committee

The need for organising the coconut industry in this country was long felt. It was, therefore, decided to set up an all-India organisation, charged with the task of resuscitating the industry. The Government of India accordingly set up the Indian Central Coconut Committee in 1945. The Committee, soon after its constitution, concentrated its attention on the production, marketing and utilisation of coconut and its products and in co-ordinating the various activities of the different aspects of the coconut industry. The Committee started two All-India Coconut Research Stations, one at Kasaragod (in South Kanara District of Madras State) to deal with fundamental problems of coconut,

A well-spaced-out coconut garden

and the other at Kayangulam (in Travancore-Cochin State) to deal with control of pests and diseases. The Committee is also financing schemes for establishing, in different States, Regional Coconut Research Stations to deal with problems of local importance, and coconut nurseries for supplying quality seedlings.

Selection of site

The best soil for growing coconut is rich alluvium or deep loam having proper soil moisture in summer and adequate drainage during rainy months. The coconut will also thrive well in fairly deep lateritic or gravelly soil and in clayey soils and on canal bunds and river banks having proper soil depth. Sandy soils in the coastal regions with sub-soil water within easy reach of the roots or where there are facilities for irrigation during the dry months are also suitable for coconuts. Shallow soils with drought conditions prevailing in summer are generally unsuitable.

Planting material

In choosing planting material utmost care should be bestowed both in the matter of the variety and the mother palms from which seednuts are to be obtained. Among the varieties met within India, the "Tall variety" is the most economic and long lived. It yields nuts best suited for copra and oil production. The husk is also suitable for conversion into fibre. The "Dwarf variety", although early bearers, are uneconomic since they are irregular in bearing and produce small nuts which give copra of inferior quality.

Planting

The site selected for new planting should be laid out into suitable plots with bunds. The planting is best done in straight rows giving a spacing of 25-30 feet between plants, depending upon local conditions. Planting is generally done in three feet cube pits filled up to about one foot with an admixture of good surface soil and sand. About 10 lb. of good ash and one or two handfuls of common salt are also added to the planting pit and the soil raked up. In low lying areas, where high water table is met with, planting of seedlings is done in shallower pits or on raised mounds, the inter-spaces between mounds being filled up with good soil as the palms grow up. In most localities seedlings, which are about 9-12 months old are planted. In low-lying areas and under certain conditions 2-3 year-old seedlings are preferred.

After-care and maintenance

The plantation should be properly fenced to prevent cattle trespass. The inter-spaces may be cropped with pulses or grain crops in rotation with green manure crops. Light dressing with ash and oilcake in seedling pits after the seedlings are well established will induce quicker growth. Regular manuring may be carried out from the time the palms start flowering, each plant may be given cattle manure (100 lb.), ammonium sulphate (3 lb.), bone meal or superphosphate (2 lb.), and muriate or sulphate of potash (2 lb.).

Pests and diseases

The coconut is affected by a number of pests and diseases. The Black or Rhinoceros beetle (*Oryctes rhinoceros*) is a serious pest of the coconut palm. It borrows into the soft tissue of the crown and eats up the tender shoots and flower buds. Hooking out the beetle from the crown and spraying the manure pits and compost heaps, where the beetle breeds in abundance, with 0.2 per cent B.H.C. are found to be effective.

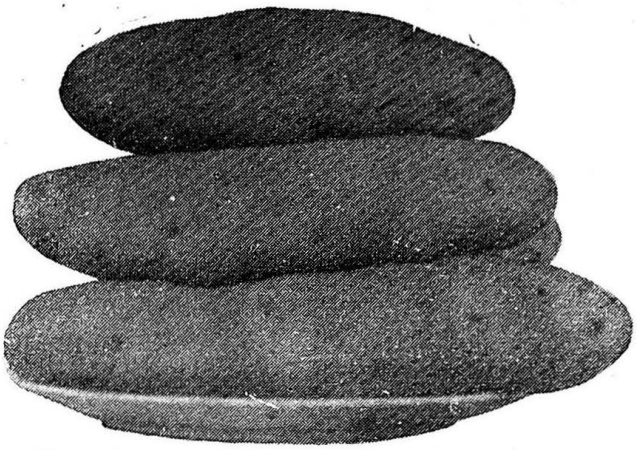
The leaf eating caterpillar, *Nephantis serinopa*, is a serious pest in some tracts. Biological control of the pest by breeding and liberation of parasites is very effective. In cases of severe infestation, spraying the affected leaves with D.D.T. or B.H.C. in concentration of 0.1 per cent is desirable. The Red Palm Weevil and rats are the other common pests of importance.

Among the diseases, bud-rot and stem bleeding are the commonest ones. Spraying with one per cent Bordeaux mixture as soon as bud-rot symptoms are noticed will be effective. Trees showing symptoms of stem bleeding should be surgically treated by chisel-ling out the affected part and applying coal tar. Better manuring and providing proper drainage facilities will provide proper environmental conditions suitable for the control of the disease. The "Root and Leaf Diseases", which are confined to a portion of the Travancore-Cochin State, can also be controlled to a great extent by spraying the affected trees with copper fungicides, preferably Bordeaux mixture, and regularly inter-cultivating and manuring the gardens.

Potato

by

Pushkar Nath



Large, long, oval tubers of an improved type of potato

FROM time to time, schemes dealing with different aspects of potato cultivation have been sanctioned and financed by the Indian Council of Agricultural Research.

Breeding work was carried out by the Indian Agricultural Research Institute at their Simla and Bhowali Stations. Work connected with selection of potato varieties for the plains was carried out by the Botany Division of the Indian Agricultural Research Institute.

Comprehensive collections were built up from time to time. These were maintained and studied at the Simla Potato Breeding Station. The collection included varieties and species secured from various sources.

Indian potato varieties

Botanical study of over 500 samples secured from different parts of the country revealed for the first time that there existed great confusion regarding the identity of varieties grown. The relative importance of different varieties, which entered the trade in this country, was unknown and the same variety was often designated by different local names and different varieties sometimes designated by the same name. The results of the study showed that although 28 distinct commercial varieties were grown, to a lesser or greater extent, in the country, yet from the commercial point of view only *Phulwa, Darjeeling Red Round, Gola, Magnum Bonum, Up-to-date* and *Great Scot* were of importance; the former three are *desi* varieties in the plains and the latter three European potatoes in the hills. Detailed botanical descriptions of varieties grown in India have been drawn up and the published information is of value to all persons interested in potato growing.

Foreign commercial varieties

A very large and varied collection of European and American varieties has been built up. The investigations have resulted in some useful contribution, particularly in the field of breeding superior varieties for conditions prevailing in the hills and plains. Foreign varieties being mostly bred to suit long-summer-day conditions do not thrive under short-winter-day conditions in the plains of India.

South American collection

Over 50 species, each sometimes represented by more than one variety, have been collected and maintained. Some of the useful ones have been utilised for breeding work particularly in connection with breeding of varieties resistant to diseases.

In *S.demissum, S.antipoviczii, S.polyadenium* and several other species genes for late blight resistance were to be found. Frost resistance was exhibited by *S.acule* and *S.demissum* and resistance to some virus diseases by *S.rybinii.* Several varieties with long dormancy period were met with in *S.andigenums* and with short dormancy in *S. phureja* and *S.rybinii.*

Breeding

The material for breeding work has been provided by the several collections mentioned above. Besides the high yield and good keeping and cooking qualities, the work soon showed that diseases were an important factor in reducing the yield of potato crop. Degenera-

tion of stocks of the commercial varieties grown in India was attributed to several virus diseases, among which leaf-roll and virus Y, X and A were considered important. The problem of late blight was also found to be of importance.

Besides these, some selected clones of exotic commercial varieties have been found valuable particularly for conditions in hills. Among these, special mention may be made of a disease-free strain of Up-to-date, nucleus stock of which was brought from Northern Ireland.

Late blight resistance

The genes for late blight resistance were discovered among the South American tuber bearing species *S. antipoyiczii* and *S.demissum* and also in a hybrid *S. demissum* x *S.tuberosum*, secured through Russian sources. Crosses with these and the domestic potato *S.tuberosum* were successfully made and the F_1 thus derived repeatedly back-crossed with the cultivated type. From a series of back-crosses, a progeny of over 5,000 seedlings was raised from time to time, and about 40 hybrids, which have shown a high degree of resistance both in the laboratory and under field conditions, were selected. Some of these hybrids approached commercial standards both as regards yield and tuber size.

Virus resistance

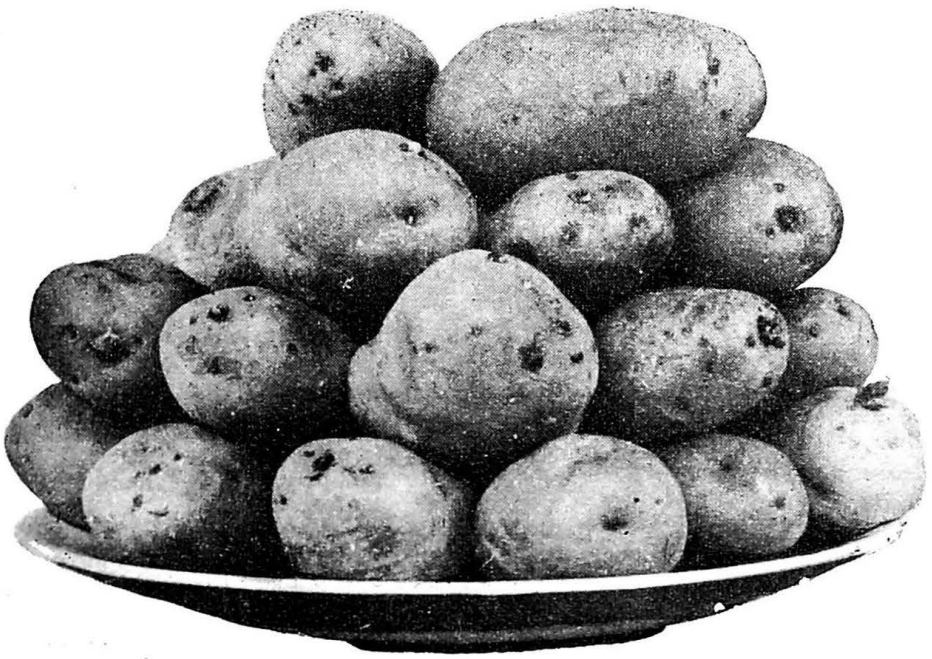
The problem of virus diseases required considerable preliminary work with a view to determining which of the virus diseases were of economic importance in the country. The work revealed that the two aphid-borne viruses, leaf-roll and virus Y, were important besides virus X and to a lesser degree virus A. Genes for resistance to leaf-roll were found to be present in a *desi* variety *Sathoo* and possibly in the imported variety *Imperia*. Material showing field-immunity to virus X and virus A was also imported and several crosses were made.

Potato propagation

Experiments were carried out with a view to devising rapid methods of potato multiplication and there studies have yielded results which have great economic possibilities.

The experiments conducted in the Botany Division of the Indian Agricultural Research Institute at Delhi with *Phulwa* and *Gola* indicated that the yield by the use of "rose end" of the tubers, though satisfactory, was very much less than that obtained by the use of half or whole tubers. It was, however, suggested that decrease in yield obtained through the use of tops could be compensated by adopting a slightly close spacing than usual.

A new method known as the "sproutling method" of growing potato through detached sprouts has been evolved at the Simla Station. It consists of raising the crop from about 1-2 inches long sprouts detached from the mother tuber. The detached sprouts are closely planted (about a month before the normal sowing season) in rich soil beds. The sproutling, when they are about 4-6 inches high are transplanted in



A good seed stock disease- ree strain of potato

the field. The yield from the sproutlings under Simla conditions approaches the yields obtained from the tubers sown in normal manner.

Each tuber when kept under suitable conditions of light and temperature has been found to yield three to five successive crops of 1-2 inches long sprouts after intervals of 20-30 days each.

Dormancy

Dormancy of potato in India has assumed a special importance as the potatoes harvested in September-October in the hills cannot be immediately planted in the plains. Experiments carried out showed that the most successful treatment for breaking dormancy was peeling of the tubers (leaving the eyes intact) and storing them in moist cover for about a week. However, this method had practical limitation in as much as it could not be used on a commercial or a semi-commercial scale. For such purposes treatment with ethylene chlorohydrine vapour for 24 hours was found to give positive response, thus making it possible to utilize the process on a commercial scale.

Photoperiodism

Many of the South American species are highly sensitive to day light conditions, some often reacting markedly to photoperiodic changes. In general, under short day conditions, most of them give better yield and show early maturity, while under long day conditions most varieties and species flower profusely and mature late. One important conclusion drawn as a result of these studies with Indian commercial potato varieties was the great varietal response to day light conditions. Some like *Nambri* and *Magnum Bonum* reacted in normal manner to short day conditions, while *Phulwa* and *Darjeeling Red Round* failed to show marked response. In other words, they were "day-natural". This would explain why varieties like *Phulwa* and *Darjeeling Red Round* flower both in the hills and plains of India and also set a reasonably fair number of tubers under both long and short day conditions.

Virus diseases

Survey of virus diseases was carried out in Kumaon, Chakrata, Kangra and Simla Hill regions. The incidence of virus diseases varied widely from 5.3 to 93 per cent, the mild type of mosaic disease being predominantly dominant. In the plains survey was carried out in several districts of Bihar, Uttar Pradesh, the Punjab and Bengal. Both severe and mild types of the mosaic were predominant, sometimes approaching 94.4 per cent.

As a result of a series of "tuber indexing" tests and subsequent analyses on different host plants, disease-free stocks of *Darjeeling Red Round* were developed and small stocks multiplied in the high hill elevation of Kufri.

As a short-term measure to step up potato production during the war period, a scheme for production of disease-free stocks was taken up during 1944-47. Under this scheme, during the three-year period, about 7,000 maunds of potato seed were produced and distributed to different States as nucleus seed for further multiplication.

Pest and diseases

It has been determined that the tuber moth, besides tunneling and producing decay of tubers, also causes leaf damage. Under storage conditions, the duration of different stages of the parasite was very short.

Among the control measures several chemical and mechanical treatments were tried and found to be effective.

Immersion of tubers in 1 per cent sanitary fluids for 15-60 minutes destroyed 60-100 per cent eggs. Immersion of tubers in copper sulphate solution, creosote, pyrethrum or pine oil was also found to be effective against eggs but only partially effective against larvae. DDT 1.5-6 per cent had a toxic effect on the moths. It also affected their longevity and fecundity.

A covering of one-inch thick sand mixed with bits of garlic (1 lb. per maund of potatoes) has given the best results when potatoes were stored on *machana* or on floor. The use of 5 per cent DDT (Geigy 33A) was found to be the most effective, lowering both the moth attack and rot. Among the other measures of control, early harvesting was found to be very useful.

The ants have also been found to be of great help. If *gur* is sprinkled on soil, ants are attracted and they immediately perform the work of cleaning the tubers of larvae, eggs and moths without damaging them.

Dehydration

The technique of dehydrating of potatoes consists of peeling, trimming and later blenching and chilling of $\frac{1}{4}$ in. thick slices. Blanching is done in hot water at a temperature between 180° and 212° F. for a period of three to five minutes. Immediately after blanching, the slices are immersed in cold water. The blanched slices are dried in commercial or home driers.

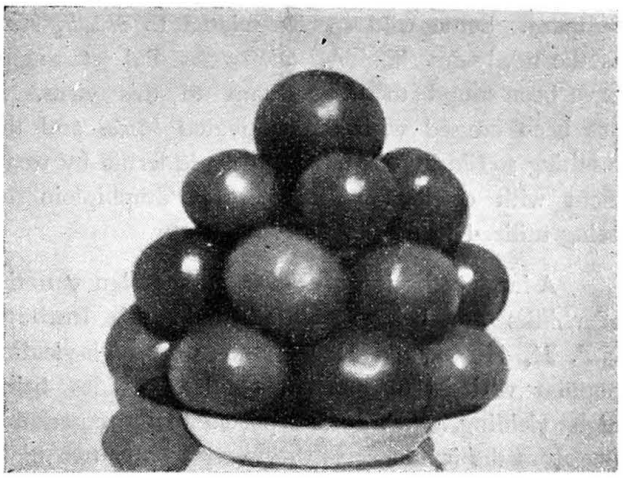
Cold storage of potatoes

It has been determined that the period of successful storage varies with storage temperature. Thus at 52° F. successful storage period is 3-4 months after which period the potatoes sprout. At 45° F. and 40° F. the successful storage period was found to be five and seven months respectively. At 35° F. the successful storage period was indefinite. Rottage of tubers (previously selected in store) was found to be extremely low at temperatures ranging between 35° and 40° F.

Vegetables

by

B. P. Pal



A collection of large well-formed tomatoes

INDIA grows a large variety of vegetables belonging to the tropical, sub-tropical and temperate groups. A majority of them constitute introductions from foreign countries in ancient or recent times. Having come into culture, selection among these vegetable stocks based on local preferences, has resulted in the establishment of a number of varieties which have since been grown in this country traditionally. Little care seems to have been exercised in the maintenance of the purity of these varieites, with the result that, although their populations represent stocks well adapted to particular soil and climatic conditions, the stands are rather impure and heterogenous. Vegetable seed production and distribution has in this country been mainly in the hands of private commercial concerns few of which gave the matter any scientific attention.

The Indian Council of Agricultural Research has financed a number of research schemes dealing with the improvement of varieties of vegetables, breeding of new varieties, improvement of cultural methods, determination of manurial requirements and control of pests and diseases. Five years ago, the Government of India located a Vegetable Breeding Station at Naggar in the Kulu Valley, in the Punjab, for work mainly on the temperate vegetables. At the Botany Division of the Indian Agricultural Research Institute, work on vegetable crop started a decade or so ago as part of fundamental researches such as those dealing with hybrid vigour and utilization of wild relatives of crop plants in plant breeding.

Utilization of hybrid vigour

At the Indian Agricultural Research Institute, vegetable crops have been under investigation, during the past decade or so, for the study of hybrid vigour in them. Marked hybrid vigour was manifested by brinjal hybrids. One of the cross combinations, "Pusa Purple", gave nearly 50 per cent more yield than the commonly cultivated varieties. Bitter gourd hybrids (*karela*) also showed heterosis. In tomato, the cross between "Sioux", an introduction from the U.S.A., and "Meeruti", an indigenous variety, has shown hybrid vigour and given significantly higher yields as compared to the parents and other commercial varieties. The work on producing hybrid onion has been recently initiated in this country. In the self-sterile root crop, radish, certain hybrid combinations have given higher yields and, as a result of several experiments, a method of inter-planting the parent varieties has been worked out for obtaining the highest percentage of genuine hybrid seed.

Utilization of wild relatives

Wild species related to crop plants are often found to possess valuable characters. At the Indian Agricultural Rescarch Institute the cultivated tomato, *Lycopersicon esculentum*, was crossed with a wild related species *L. pimpinellifolium* from South America. This wild species possesses high vitamin C and sugar contents. From the crosses, a number of hybrids have been evolved; one of them, viz., N.P. Hyp. 6, produces delicious fruits about thrice as large as a cherry and rich in vitamin C and sugar contents. In the cultivated *bhendi*, *Abelmoschus esculentus*, the

yellow vein mosaic disease caused by a virus is very rampant. Some wild species related to *bhendi*, such as the newly-described A. *tuberculatus* Pal *et* Singh, have been found to be resistant to this virus. It has been crossed with the cultivated *bhendi* and the resulting sterile hybrid has been made fertile by treatment with colchicine; this fertile "amphiploid" is being utilized in further breeding work.

A large collection of Indian and foreign varieties of chillies are being maintained in this Institute. N.P. 34, 41, 46, and 51 are among the high-yielding popular varieties of pungent chillies. Besides being high yielding, N.P. 46 is reported to be remarkably free from the incidence of thrips. Recently two high-yielding strains, N.P. Hybrids 5-1-5 and 17-1-1, have been evolved; these strains, especially the latter, are suitable for the production of green chillies for the vegetable market. Among non-pungent vegetable types, two American varieties, World Beater and Bell Pepper, and a Russian variety, R. 449, have out-yielded local varieties in trials at Delhi and Pusa.

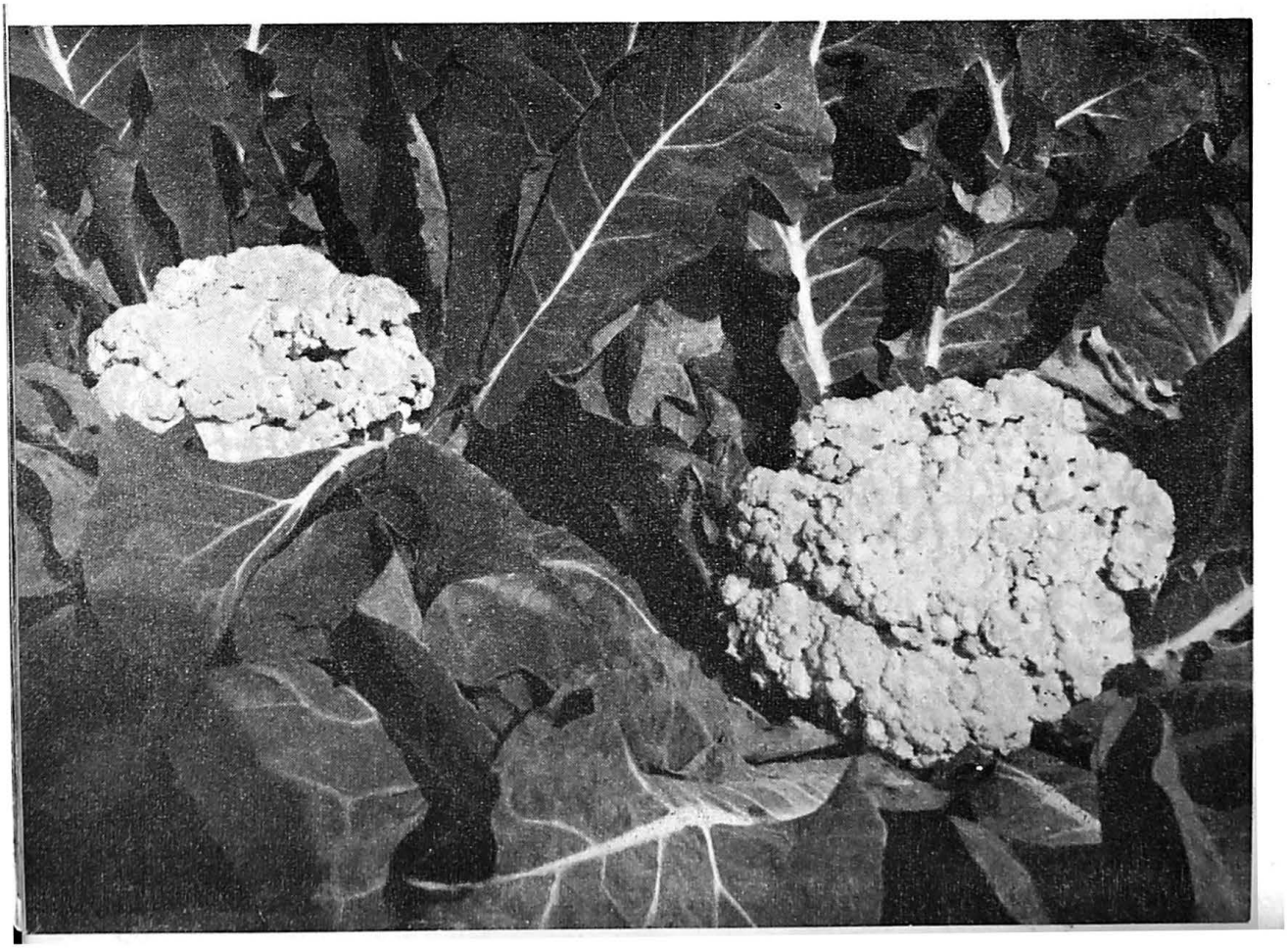
Plant introduction

At the Indian Agricultural Research Institute, a nucleus organization for the exploration and introduction of useful plants was established in 1946. Since then, extensive collection of varieties of crop plants, including vegetables and their wild relatives have been built up. Many among them have been found to be very promising and worthy of direct commercial exploitation in this country. Instances deserving special mention include the American tomato variety "Sioux", the Chinese sweet potato variety, F.A.17, an early-fruiting vegetable cowpea variety from the Philippines and an early variety, "Early Badger", and two midseason varieties "Dolwiche Commando" and "Bonneville", of garden peas received from America. In tomato, out of nearly 200 exotic varieties and 100 indigenous accessions, the American variety "Sioux" and the indigenous selection called "Meeruti" have established their superiority in several respects. F.A.17 has given outstandingly high yields. A seedling selection has been developed from hybrid seed imported from the U. S. A.; it produces orange-fleshed tubers rich in carotene (which is a procursor of vitamin A) and it is now being multiplied.

Work on other vegetables

This Institute has also built up collections of indigenous varieties of a number of vegetable

A new variety of cauliflower



crops. From amongst these collections, several useful strains have been isolated and selected which are now recommended for cultivation. In brinjal, the study of a comprehensive collection comprising about 50 indigenous and exotic varieties, has indicated that selection and breeding within the indigenous material would offer greater scope for improvement in this vegetable. A collection of about 40 indigenous and exotic varieties of *bhendi* has been built up. Among the indigenous ones, a selection having five-edged fruits and obtained from West Bengal under the name, "Sabour Selection", has given the best all-round performance and is recommended both for growing during the hot weather and the rainy season. From crosses of this variety with an American round-fruited variety, "Green Velvet," a number of selections have been made some of which are about 15 days earlier in fruiting than "Sabour Selection".

India has been given the credit of producing some good strains of hot weather cauliflower. One such strain has been developed at the Institute. Good quality seeds of this variety have been produced at Delhi. Among the varieties of bottle gourd grown for the summer crop, an indigenous long-fruited selection, which has been named "Summer Prolific", has given the best yields. In *sem* (*Dolichos lablab*), a selection from Delhi material has appeared to be the best in comparison with a number of other varieties obtained from several centres in northern India. Among the *Luffa* gourds (*torai*), a selection made from the material of smooth gourd obtained from Bihar and named "Patna Early" and another of ridge gourd named "Neemuch" have given good performances at Delhi.

Central Vegetable Breeding Station, Naggar (Kulu)

This station has been concentrating its attention mainly on the production of seed of some well-known foreign varieties of cabbage, knol khol, beet, carrot, radish, turnip, beans and a few other less important vegetables. A limited amount of selection work has also been done.

Work on vegetables in the States

Punjab: This is among the few States in India where considerable work on vegetables has been in progress for some years past. Varieties of peas, carrot, radish, turnip, cabbage, knol khol and sweet potato are on the list of approved seeds. Since last year, a scheme financed by the Indian Council of Agricultural Research has also been in operation for work on agronomical and breeding aspects of vegetables like onion, garlic, chillies, bitter gourd, etc.

Uttar Pradesh: The selection and isolation of pure lines from the material collected from Uttar Pradesh and other States, as also from abroad, is in progress in crops, such as tomato, brinjal, cauliflower, *bhendi*, *luffa* gourds, *parwal*, pumpkin and bottle gourd. Attention is also being paid to work on the fungal diseases and pests of these vegetable crops.

Other States: The work on vegetables there consists mainly of selection in tropical vegetables for the production of varieties suited to local conditions. Attempts at producing seeds of winter cauliflowers, which are mostly imported from foreign countries, are reported to have met with a good measure of success at Pachmarhi (Madhya Pradesh).

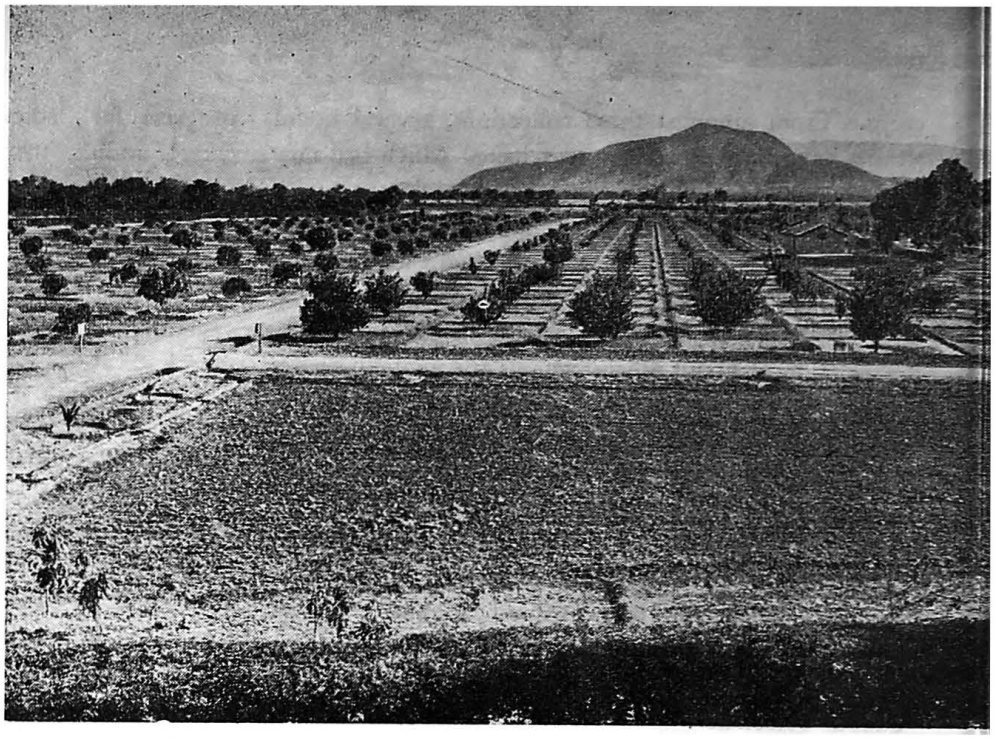
Research programmes have been undertaken which include improvement of varieties, breeding of new varieties, improvement of cultural methods, manurial requirements and control of pests and diseases. Breeding of leafy vegetables has also attracted attention as for example at Poona (Bombay State) work on *palak* (*Beta vulgaris*), *methi* (*Trigonella foenum-graecum*) *chakwat* (*Chenopodium album*) and *rajgira* (*Amaranthus blitum*), has been undertaken. Work is also in progress on some of the root crops, such as the sweet potato (*Ipomoea batatas*), in the Punjab, Mysore, Travancore-Cochin and Bombay and on *Colocasia* (*arvi*) in the Punjab. During the past few years, work has been in progress at Niphad in the Bombay State on the production of hybrid seeds in onion.

It may be said that agronomic aspects of vegetable production have so far received meagre attention in India and it was, therefore, natural for the recent Indian Council of Agricultural Research schemes on vegetable improvement to focus attention on them. Unlike most agricultual plants, vegetable gardeners are concerned with the season in relation to the market in order to secure higher premiums.

Fruits

by

K. C. Naik



A view of a section of the citrus variety collections (right) and of the mango variety collections (left) at the Fruit Research Station, Kodur

THE fruits grown in the country run into thousands of varieties, each with its own peculiarities and requirements. Accordingly, only some of the most outstanding crops and research activities are dealt with in this review.

Mango

Mango is the chief fruit crop of the country. Among the earliest research schemes sanctioned by the Council of Indian Agricultural Research were those on the cold storage of fruits at Poona and on some of the tropical fruits in Madras, Bihar and Bengal. All these schemes included problems of particular import to the mango. Investigations on varietal differences, propagation methods, bearing tendencies, pollination and certain agronomic, storage, preservation and pathological aspects received special attention under these schemes, while the State Departments of Agriculture supplemented these studies with contributions on subjects of primarily local interest. These conjoint efforts have helped to determine the most suitable varieties and the optimum propagation practices for each of the more important regions of the country. Standardised descriptions of varieties have also been recorded in some States.

By suitable breeding work, Madras has already succeeded in obtaining a few valuable hybrids and Bihar has also reported encouraging success. Some methods of renovating and rejuvenating orchards have been worked out in Bihar, while in Madhya Pradesh and Bombay, the State Departments have determined optimum methods of top-working. Mango necrosis has received considerable attention. Standard recipes for the preparation of a variety of mango products have been worked out. Cold storage experiments have determined the optimum storage life and storage conditions for many varieties of mangoes as well as several other Indian fruits. In keeping with the general advancement towards a more effective control of insect pests with the use of DDT, BHC and similar compounds, more satisfactory measures for dealing with several pests of the mango have been worked out.

Banana

Banana has received adequate attention by research workers only during the last few years. A cyto-genetic scheme was in progress first at Calcutta, and later at Poona. It has contributed preliminary information useful to the breeder of the crop. Some exploratory work on banana fibre and banana dehydration has also been attempted in Madras, while recently the Food Technological Institute, Mysore, has developed a method of preparing starch out of banana rhizome. With the establishment of a Central Banana Research Station at Aduthurai (Madras), with its two substations in West Bengal and Bombay, a steady and accelerated progress of research on this crop is envisaged.

Citrus fruits

This group of fruits enjoys commercial importance in the country far more than is disclosed by its acreage. Descriptions of many of the cultivated and indigenous varieties are now available in some of the major States.

A number of nursery technique and rootstock trials, notably those carried out in the Punjab, Madras and Assam, have furnished information of considerable practical value. Manurial experiments in the Punjab have been another source of practical information to the growers. Much headway has been made in the control of pests and diseases, but die-back and premature decline of citrus trees are yet unsolved problems. Investigations on cold storage have determined the optimum storage life of several commercial citrus varieties. Grading and marketing problems have also received attention.

Hill fruits

There has been a concentrated attempt to improve the deciduous fruits grown over a small area of roughly 10,000 acres, first with the aid of comprehensive research in horticultural, chemical, entomological and mycological problems and then through a planned development programme to exploit the results of research. Apple was the most important of the crops worked upon. In Kashmir, special attempt was made to deal with two specific problems, *viz.*, the control of the dreaded San José scale, and the identification of all the varieties grown in the State. Spraying with 1 : 5 dilute diesel oil emulsion has been found very effective in controlling San José scale. The survey carried out to identify the different varieties has also been useful as a preliminary to the popularisation of selected fruits.

An orchard of an improved variety of Kaghzi limes

Other fruits

Among the remaining fruits, grape has perhaps figured more prominently in the research programmes. Much work on viticultural practices has also been attempted by the State Departments of Agriculture in Bombay, the Punjab and Madras.

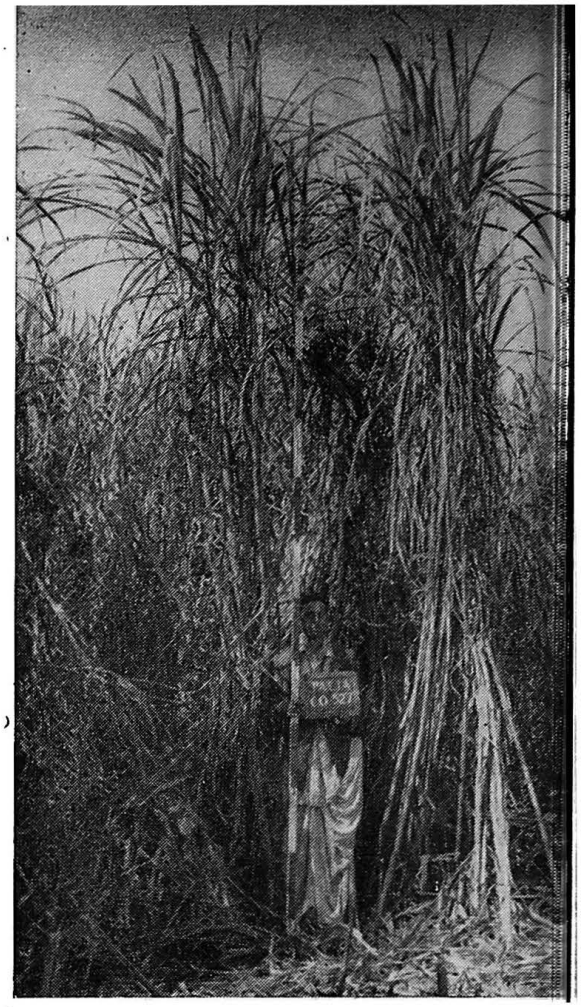
A co-ordinated scheme of research has been sanctioned for the improvement of a very important dollar earning crop, *viz.*, cashewnut, with a central station at Mangalore (Madras) and regional centres in Travancore-Cochin and Bombay States.

Basrai variety of banana

Sugarcane

by

Nand Lall Dutt



A crop of Co. 527

FISCAL protection to the sugar industry was granted in 1932 and in the short space of six years the number of sugar factories rose from 32-131. The imports dwindled from 586,000 tons in 1931-32 to 21,648 tons in 1937-38 and practically ceased in 1942-43. The production of sugar increased from 471,000 tons in 1931-32 to 1,586,600, tons in 1951-52. The area under sugarcane increased from 2,905,000 acres to 4,573,000 acres during the first six years after protection. In the same period the yield of cane per acre rose from 12.3-15.6 tons owing mainly to the introduction of improved sugarcane varieties.

The responsibility of guiding sugarcane research rested mainly with the Indian Council of Agricultural Research from its inception in 1929 till November, 1944, when this function of the Council was transferred to the Indian Central Sugarcane Committee. A chain of sugarcane research stations was established in the various States by the Indian Council of Agricultural Research to try out improved varieties under the varying soil and climatic conditions and to conduct research on agronomical problems. The establishment in 1936 of the Indian Institute of Sugar Technology at Kanpur is another contribution by the Indian Council of Agricultural Research to the cause of sugar industry.

The greatest landmark in sugar cultivation and industry is the evolution of the improved sugarcane varieties bred at the Coimbatore Institute. As is well recognised, the special feature of the sugar industry is its close connection with agriculture.

Sugarcane Breeding Institute, Coimbatore

The Sugarcane Breeding Institute was established in 1912. The utilisation of the wild *Saccharum spontaneum* in breeding has resulted in the production of canes which are hardy and by virtue of which they are adapted to varied soil and climatic conditions. Practically all the Coimbatore canes possess in their constitution, directly or remotely, the genetical complements of the wild *Saccharum spontaneum*. The varieties Co. 312, Co. 313, Co. 421 and Co. 453, among others, have been growing well in the sub-tropical climatic conditions, while Co. 419 has become the universal cane for the tropical parts. Among the recent varieties, Co. 630, Co. 644, Co. 659 and Co. 686 combine in themselves early maturity and fairly high tonnage. Among late maturing varieties, Co. 331 in the earlier years, and recently Co. 453 claimed some attention. Intergeneric hybridization has been successfully attempted utilising *Sorghum* and lately bamboo, *Sclerostachya*

and *Narenga porphyrocoma* in the breeding programme. To reduce the element of chance and bring sugarcane breeding in line with other crops, attempts are being made in the cyto-genetical section to study the constitution of the noble cane, *Saccharum officinarum*. Photo-periodic, manurial and irrigational studies have been in progress to induce flowering in non-flowering varieties, and hasten or delay flowering in others and a certain amount of success has been achieved in this direction.

State research stations

In many of the State research stations work has been in progress on varietal, cultural, manurial, irrigational, chemical, physiological, mycological and entomological problems connected with sugarcane, and the more useful results obtained have been recommended to the growers for adoption.

Varietal studies

The new Coimbatore canes released every year are tested at the State research stations and those which are found promising are released for cultivation. Based on such tests 25 improved varieties are now in cultivation in different parts of India.

Cultural methods

Experiments have been conducted on the method and time of planting, spacing, seed rate per acre and inter-cultural operations. Planting on flat and earthing up during the monsoon have given good results in North India. In the tropics trench planting is advocated to be the best. Planting the crop earlier than the normal practice of cultivators, *i.e.*, in February, has given better results.

Manurial trials

Manurial experiments conducted at the research stations have indicated the effectiveness of nitrogenous manures, while phosphatic and potassic manures have resulted in distinct advantage only in a few places in India. Experimental work has shown that farm-yard manure or compost is mainly a soil improver; their value as nitrogen supplier being negligible. Green manuring prior to sugarcane cropping has been found to increase the yield.

Irrigation

Sugarcane being essentially an irrigated crop, the optimum requirements of water have been studied in certain experimental stations. In Uttar Pradesh it has been found that within certain limits, frequent light irrigations are better than fewer irrigations with larger quantities of water per irrigation. Very useful work has been done at Padegaon, Bombay, as a result of which it has been found that the cultivators there usually over irrigate the crop which affects the yield adversely.

Diseases and pests

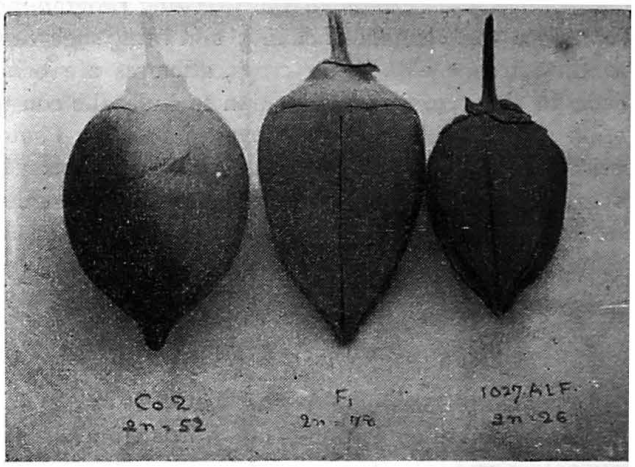
Varietal resistance to red-rot and smut, the two major diseases of cane, has been the main problems of study. In the light of the results obtained at the Indian Agricultural Research Institute, practical schedules have been drawn up giving the characterisitic symptoms and control measures for red-rot, smut and mosaic. Wilt disease has received attention at the Pusa Research Station. The usefulness of *Trichogramma minutum* in controlling the stem borer has been demonstrated in certain centres. Simple agricultural practices like earthihg up of young canes and harvesting the canes by digging have been found to be effective in certain tracts in controlling borers. Spraying the cane crop with chemicals like DDT, BHC and similar compounds has given encouraging results in the control of certain pests like Pyrilla and white fly. Stripping of leaves has proved effective in certain tracts for controlling Pyrilla.

Co. 419 variety of sugarcane

Cotton

by

Kalidas Sawhney



Boll of hybrid between an American (Combodia) and an Indian cotton (1027 A.L.F.) as compared to its parents

THE last quarter of the 19th century witnessed the beginning of a growing demand for raw cotton first from Indian mills and then from mills in Japan. As a result of this, the average annual production of cotton in India (including Burma) increased from 1·6 million bales for the quinquennium ending 1882-83 to 3·7 million bales during five years ending 1906-7. The first decade of the present century experienced a steady increase in the production, export and mill consumption of cotton.

The bulk of the cotton grown in India was of mixed short staple Asiatic varieties. The conditions arising out of the First World War impressed upon the Government of India the necessity of increasing the production of long staple cotton having better spinning qualities. Consequently, the Indian Cotton Committee was appointed in 1917-18 to go into the question of cotton policy and cotton trade. This Committee stressed the lack of organisation of cotton trade and of co-operation between it and the Agricultural Departments.

In accordance with the recommendations of this Committee, the Indian Central Cotton Committee was set up in 1921, and two years later, a legislation was enacted by the Government of India giving statutory status to the Committee and providing statutory funds by the levy of a cess on cotton consumed in Indian mills or exported from the country. This Committee, with various amendments to the original Act, is charged with the promotion of agricultural and technological research in cotton and problems relating to industry and marketing.

Studies in cotton genetics, inheritance of plant characters and modern classification of Indian cottons have been undertaken on a comprehensive scale at the Institute of Plant Industry, Indore, and a few other research stations. Genetical investigations have comprised studies on chlorophyl deficiency, lintlessness, fuzz colour, leaf and stem pigmentation, jassid and wilt resistance and inheritance of quantitative characters. This work of fundamental nature has not only added to the knowledge of cotton genetics, but has also proved of value to the cotton breeders in the country in their crop improvement work. Research has also been done on the technique of applying statistical methods to studies on cotton genetics as well as cotton breeding. Mention may be made in this connection of the "progeny row" technique evolved at Indore, and of studies in field technique with reference to incomplete block designs, sampling in field experiments and discriminant functions for plant selection. The physiological research has been responsible for finding remedies for partial crop failures of American cotton in areas now transferred to West Pakistan. Work has also been done to obtain, as far as possible, precise knowledge of the inter-relationship between soil and climatic factors and the different varieties of cotton, and to utilise the knowledge thus gained for improving the yield of indigenous as well as exotic varieties. The causes of "Red Leaf" of cotton and the effect of trace elements on cotton plant have also been investigated.

The biggest success which the cotton research has had so far is the production in practically all the major cotton growing States of improved varieties of cotton. The work done during the past 25 years jointly by the Indian Central Cotton Committee and State Governments has not only produced many long stapple American varieties grown in the West Punjab and Sind (now included in Pakistan) but it has also produced the valuable varieties grown in the Indian Union. The varieties like Punjab 216 F., L.S.S. and Punjab 320 F. of the East Punjab, 35/1 of Uttar Pradesh, Jarila, Buri 0394 and H. 420 of Madhya Pradesh, Suyog, Vijaya, Laxmi, Virnar and Jaydhar of Bombay, Gaorani 6, Gaorani 12 and Parbhani-American of Hyderabad State, Coconada 1, Westerus 1 and Rayalaseema 1 of Andhra, and Karungani 2, Karungani 5, Madras-Uganda 1 and Madras-Uganda 2 of Madras State are well-known to both the cotton trade and the textile mills. In the production of these improved types, the workers have had recourse not only to straight selection from the existing varieties, and importation and acclimatisation of exotic types, but they have also had to resort to intra and inter-variety hybridisation as also to crossing of different species. Help has also been taken of artificial variations induced by X-ray treatment of seed and the use of colchicine on growing points of plants and flower buds.

The State Governments and the Indian Central Cotton Committee have during the past many years operated jointly numerous schemes for the large-scale multiplication and distribution of pure seed of improved varieties. The area under the improved varieties at present forms about 55 per cent of the total area of 17 million acres under the crop. Similarly, the medium and long staple varieties now form about 60 per cent of the annual production as against 25 per cent in 1920. It has been estimated that by growing improved varieties, the cotton farmers can earn an additional income of about Rs. 9 crores per annum.

The average yield of cotton per acre in India is deplorably low. The need for increasing the yield in India by intensive cultivation is recognised and extensive research has been done on the use of manures, irrigation of the crop, and improved agronomic practices

A cotton crop with fully opened bolls containing mature seeds with lint of good quality

such as bunding of fields, early and proper preparation of land, early sowing, introduction of groundnut before cotton in the existing rotation, growing cotton as a second crop after rice and application of crop protection measures. Similarly, the principal insect pests and diseases of cotton have been studied in detail, and measures have been worked out for controlling jassids, boll-worms, leaf rollers, aphis, etc. Furthermore, varieties resistant to wilt-disease have been produced. During the past three or four years special schemes have been operated to extend the use of fertilisers and the adoption of other measures of intensive cultivation.

Comprehensive technological investigations have been conducted to determine the fibre properties and spinning performances of improved varieties produced in the country. A special technique has been developed to conduct reliable spinning trials with lint samples weighing only a few grams. Furthermore, correlations have been established between fibre properties and spinning performance to predict the latter with fair accuracy. Several problems of fundamental and applied nature connected with the ginning, storage and handling of cotton have been investigated. Research has also been carried out on the effects of different manurial, irrigational, rotational and cultivation treatments on the fibre properties and spinning performance of improved varieties of cotton.

Besides crop improvement and extension and the technological work mentioned above, serious attention has also been devoted to the maintenance of the purity of new varieties, improvement of ginning and marketing, and prevention of the entry of cotton pests and diseases from foreign countries. Some legislative measures have been enacted by the Central and State Governments in this connection.

Comprehensive crop cutting surveys have been conducted to obtain more accurate estimates of yield per acre and total annual production of cotton in different States.

The supply of medium and long staple cotton was adversely affected by the partition of the country in 1947. Large tracts growing medium and long staple cotton were transferred to Pakistan. While the supply position deteriorated in this way, the demand for raw cotton was almost unaffected because 98 per cent of the textile mills continued to remain within India. The need for increasing cotton production within the country assumed great importance. Accordingly, the Central Government in co-operation with the State Governments launched out a "Grow More Cotton" programme with effect from 1950-51 season. The campaign has completed four years and the production has increased from about 29 lakh bales in 1949-50 to about 40 lakh bales in 1953-54. The latest available trade estimate of production for 1953-54 season is 45·3 lakh bales. Much of this additional production of cotton is of better quality.

Jute

by

B. C. Kundu

Green jute stems obtained from broadcast and line-sown plots

DURING the last 25 years a large amount of research work on breeding, genetics, cytogenetics, anatomy, physiology, agronomy, soils, retting, diseases and pests has been done mainly with a view to increase the yield per acre and improve the quality of jute.

Genetics of jute

Intensive studies on the inheritance of different characters particularly the anthocyanin pigmentation patterns in cultivated species of *Corchorus* which form an important diagnostic character have been made. In *C. capsularis*, the manifestation of anthocyanin pigmentation is very varied and the plants range from full green to full red. Nine anthocyanin pigmented types in addition to several full green types have been established. *C.olitorius* plants are either full green or full red, and two pigmented types, in addition to one full green type, have been established.

Detailed studies on the inheritance of pod shape, branching habit, stipule character, bitter taste, corolla, anther and seed coat colour have also been carried out.

Breeding of jute

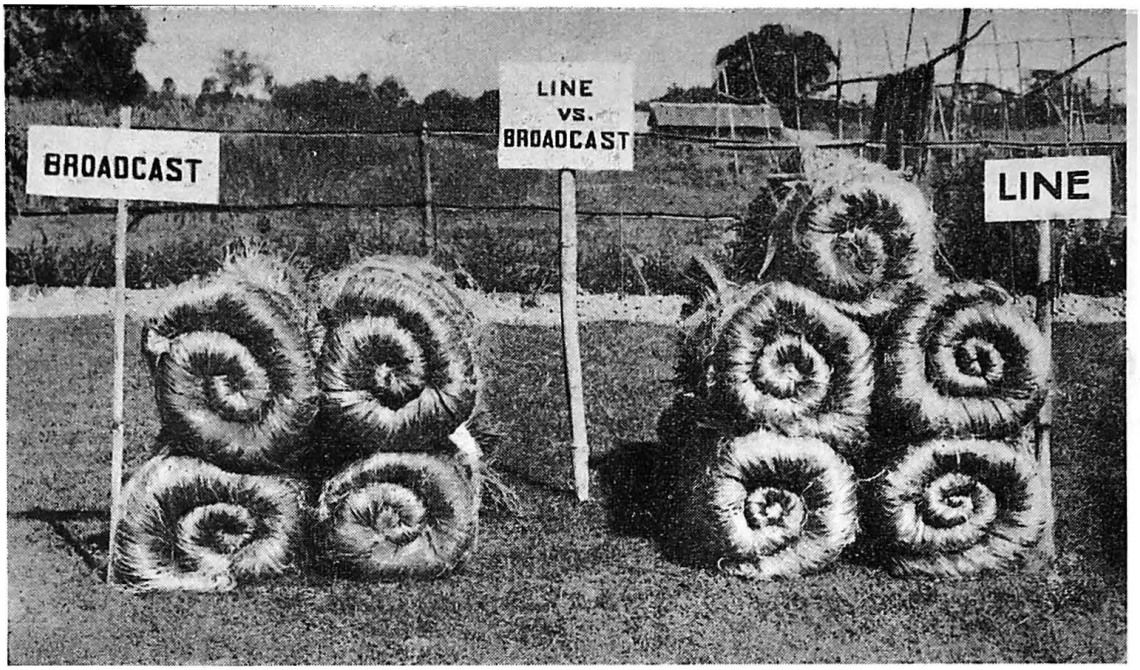
As jute is a bast fibre crop and is normally harvested long before the seeds mature, both fibre of good quality and seed cannot be obtained from the same plant. So, the criterion of selection has been based on the height and thickness of the plants.

Two main considerations in the improvement of jute are the yield and quality of the fibre, both of which should progress simultaneously. Jute plants generally require a fairly long vegetative period in order to attain a good height and stem thickness; hence late maturing types usually yield more. While such late types are usually good yielders, they are reported to suffer somewhat in quality.

Colour, lustre and softness are concomitant with good quality of fibre. Early maturing types of *capsularis*, like *Fanduk*, give a superior quality fibre, and plants of such early types with a short vegetative period are usually thin and not very tall; consequently they yield low.

Improved olitorius strains

Strain O-632. This is a high yielding, sparsely branched full green type evolved by the Jute Agricultural



Jute fibre from broadcast and line-sown plots

Research Institute. Though it takes only about 10 days more than the strain C.G. to mature, on the average it yields about 30 per cent higher and gives fibre of better quality.

Strain O-753. This also is a full green strain evolved by the Jute Agricultural Research Institute and is similar in appearance to 0-532 and yields only about 2 per cent less. In fibre quality this is similar to C.G.

Strain O-620. This is a light red type evolved by the Jute Agricultural Research Institute. It matures about the same time as C.G. but yields about 20 per cent higher giving fibre of the best quality among the cultivated *olitorius* types.

Improved Corchorus capsularis strains

Strain C-212. This is a strain evolved by the Jute Agricultural Research Institute. It matures about a week earlier than strain D-154, a standard strain and on the average yields about 11 per cent higher than D-154. The quality of the fibre of this strain has been considered to be very good. It is a full green type. Among *capsularis* strains, this is at present the highest yielder.

Strain C-321. This is an early quick growing type evolved by the Jute Agricultural Research Institute. It matures about three weeks earlier than D-154 but yields slightly less. It is a copper red type with stem coloured uniformly copper red except at the tip where it is green. The fibre of this strain is of very good quality. This strain is very suitable for double cropped (jute-paddy) areas and flooded regions where early harvest is desired.

Physiological investigations

The vegetative growth and development as well as yield of fibre are greatly influenced by the time of flowering. Satisfactory yields are obtained when sowings are done between March 16 and May 1 for *capsularis* and April 15 and May 16 for *olitorius*.

Response to pre-sowing cold treatment of seeds is manifested by delayed germination and production of more green pigments in the leaves and more vigorous growth in the early stages; there is no significant effect on the date of flowering. *C.capsularis* can withstand natural drought better than *C.olitorius* in early stages of growth, even in the case of drought resistance artificially induced by alternate soaking and drying of seeds. More fibre is produced in the early stages than in the later stages of growth when more wood is formed. *Olitorius* produced more wood and showed a lower percentage of fibre production in each stage in equal lengths of stem than those of the corresponding stages of *capsularis*.

Seeds of both *capsularis* and *olitorius* cannot tolerate a concentration higher than 1·0 per cent sodium chloride and even at this strength there is preceptible delay in germination.

Nitrogenous manures and fertilisers are directly responsible for increasing the yield of jute fibre. Application of 20-40 lb. nitrogen (available) has been found to be most economic and the yield increases by 30-200 per cent. A higher percentage of increase in yield is not uncommon in soils of lower fertility.

Jute responds to the application of all inorganic nitrogen fertilisers and most of the organic manures. Amongst organic sources tried so far, town compost has been found to be the best and comparatively lower responses were noticed with sludge or farmyard manure. Amongst inorganic sources, ammonium sulphate has so far given very encouraging results. It would appear that a mixture containing 20-60 lb. of available nitrogen both from organic and inorganic sources is very suitable for jute.

Potash manures were not found to have any direct effect on the yield of jute fibres. But it has been found to increase the yields by checking diseases. It appears that 25-50 lb. K_2O from muriate of potash is beneficial.

No positive responses were observed from phosphate application so far as yields of fibre are concerned.

Row cropping of jute

Jute responds very effectively to inter-cultural operations which are essential for satisfactory growth of the crop. Row cropping of jute ensures a higher yield and uniform quality of fibre at a much lesser cost as compared with the usual broadcast method of growing jute. A spacing of 12 inches between rows and one to three inches between plants in the row has given best results.

When jute is sown in lines, inter-culture between rows can be given by hand hoes, and the cost of weeding and thinning operations is reduced by more than half. Seed rate is also reduced to half. The total cost of production in row cropping is considerably reduced.

Results show that the fibre yields in line plots give considerable increases (ranging from 2·8-6·7 maunds of fibre per acre, or 12·7-30·2 per cent with *capsularis*, and 2·9-4·3 maunds per acre or 11·2-16·3 per cent with *olitorius* jute) over the yield from broadcast grown crop.

Double cropping

Double cropping experiments on the single cropped *aman* paddy lands with jute as the first crop and paddy as the second have shown that yield of paddy was not affected, or affected to a very small degree if at all, provided the transplantation of paddy was done at the proper time.

Jute pests and diseases

Seeds, roots and all parts of the plant body are subject to attack by pests and diseases, and the yield as well as quality are affected.

Fungi causing diseases are *Macrophomina phaseoli* (Maubl) Ashby, *Sclerotium rolfsii* and *Diplodia corchori*. Jute plants often are attacked by virus causing chlorosis.

The most serious and widely prevalent disease of jute is caused by the fungus *Macrophomina phaseoli* (Maubl.) which attacks the plant at all stages of growth. According to the parts of the plant attacked, and nature of attack, terms like seedling-blight, stem-rot, collar-rot and root-rot are used to denote the disease. Detailed biological studies on the nature and extent of damage have been undertaken and effective control measures found out.

Of the pests causing heavy damage, the following may be mentioned: *Anomis sabulifera* Guen (Jute semilooper), *Diacrisia obliqua* WIK (Hairy Caterpiller), Jute mites, *Apion corchori* (Jute apion) and *Laphygma exigua* (Indigo caterpiller) and the recently recorded *Nupserha bicolor* Spp. *postbrunnea* (ring pest).

Quality of jute

In judging the quality of fibre the following characters are usually assessed: (*i*) length, (*ii*) strength, (*iii*) colour, (*iv*) lustre, (*v*) percentage and quality of cutting, (*vi*) proportion of faults, such as roots, specks, knots, runners, hard crop, etc. and (*vii*) such general qualities as fineness, stiffness and hardness. The factors responsible for improved quality for jute fibre falls mainly under two heads: (*a*) non-controllable factors like environmental conditions, particularly soil and climate and amount and quality of retting water available, and (*b*)controllable factors like variety, improved methods of cultivation and methods of retting and extraction. Under a given environmental condition, various factors like the variety, inter-cultural practices, manurial practices, stage of harvest, uniformity of the crop, diseases and pests, steeping and retting conditions and extraction methods contribute towards the quality of fibre. Other conditions being equal, uniformity of the crop and retting conditions are considered very important.

The most important factor which affects the quality of jute is retting. For the best results in retting, the bundles should be of about eight inches diameter and the layers of bundles in the "steep" should not exceed three. Quicker retting, which usually ensures better quality is generally obtained during the earlier hotter months. Use of ammonium salts and phosphates accelerates the process of retting. Extraction of fibre from single plants yields better quality than extraction bundle-wise. Investigation into the causes of discolouration of fibres during retting has revealed that tannic acid present in the jute plant and iron in the retting water combine to produce "shyamla" or dark colour in fibres. The volume of water in relation to steeped jute is important. It has been found that for the best results the volume of water should be at least 30 cft. for every maund of jute steeped. Repeated and frequent steeping in the same ditch should be discouraged.

Fibre crops

by

S. W. Mensinkai

R. B. Deshpande

Dressing and grading of green sann-hemp

THERE are 300 fibre plants other than jute and cotton. Of these sann-hemp fibre and to some extent *Aloe* fibre (*A. cantala*, *A. veracruz* and *A. wightii*), sisal and palmyra are produced on a commercial scale. The total area under these fibre plants may be over 8,98,000 acres.

Flax, ramie and *Hibiscus* fibres constitute the textile fibres, while sisal, cotton bast fibre, *Aloe*, sann-hemp, *bhendi*, *Thespesia*, *Sesbania*, banana, pine-apple and *dhamani* (*Grewia tiliaelfolia*) form the cordage fibres, and palmyra fibres are the brush fibres.

Textile fibres

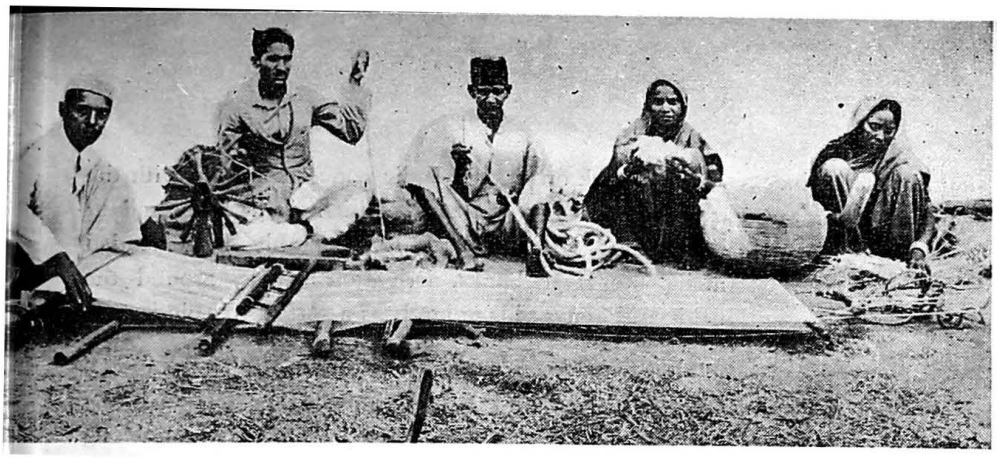
Of the textile fibres, *ambadi* (*Hibiscus cannabinus*), also known as the Deccan hemp, *mesta*, *sheria*, *pundi* and Bhimlipattam jute, is the most important as a jute substitute. The earliest work on this crop was done by the Howards who isolated eight types. Of these, types N.P.3 and N.P.6 have been found to be the best. A number of early maturing strains possessing good height and growth habit have been evolved at the Indian Agricultural Research Institute by crossing N.P. 6 with a very early-maturing, dwarf variety imported from Russia. Technological tests have shown that the best *ambadi* fibre can be mixed up to 50 per cent with jute.

Roselle (*Hibiscus sabdariffa*) is known as red roselle, green roselle and *lal* roselle. In 1927, a new variety of roselle (*Hibiscus sabdariffa* var. *altissima* Wester), called N.P. Sab. 5, was accidentally introduced into India from Java with the seeds of a leguminous fodder crop imported by the Indian Agriculture Research Institute. This variety was found to do well in Bengal, Bihar, Madras and Assam. The fibre of this variety was harsh and coarse, but its strength was comparable to that of jute. The variety was superior to the Deccan hemp.

Ramie (*Boehmeria nivea*) is one of the old textile fibres known to the East. Its utilisation outside India and its commercial uses are recent with the invention of a decorticating machine in America only a few years ago. Though one of the best fibres, it presents certain technological difficulties which offset the development of a large-scale industry. These difficulties are being overcome and ramie promises to have an industrial future in the next few decades. The greatest demand for ramie is for blending with other fibres like wool, cotton, silk and rayan.

In Bengal, seeds of rhea received from Russia were tried. This variety sets seeds well and can be propagated easily. But for the difficulty in degumming, rhea seems to have a great possibility in Assam.

Several attempts have been made in the past to cultivate flax in India, but all these attempts have ended in failure.



Linseed fibre in village industry

In 1924, the Indian Agricultural Research Institute imported seeds of the well-known Irish flax variety J.W.S. which is still being maintained. Its seeds are being distributed to a limited extent. In 1928, the Linen Industry Research Association sent to the Director of Agriculture, Bengal, seeds of two flax varieties, *viz.*, J.W.S. and of "Riga". These were grown at five centres. The results indicated that under suitable conditions Bengal can grow flax capable of giving as high a yield of fibre as in Northern Ireland and of a quality equal to the best type of Irish flax.

In 1936-37, the Indian Council of Agricultural Research sanctioned a scheme for a period of five years for the extraction of flax fibre in Bengal. Seeds of "Liral Monarch" were imported and grown in different parts of India, but the fibre was rather dry and brittle in some cases and weak in others.

During the last war, the Supply Department, in co-operation with the Bengal and Bihar Governments, drew up a scheme for flax production for which large quantities of seeds of flax were imported from Belgium and costly machinery was obtained from the United Kingdom and installed at Pusa (Bihar). The imported seeds failed to germinate.

Several attempts have been made in the past to utilize linseed fibre, but none of these appears to have actually led to its commercial utilization. The most noteworthy experiments in this direction were carried out at Nagpur (Madhya Pradesh) under a grant from the Indian Council of Agricultural Research. From the results of these experiments the conclusions drawn were that the linseed fibre was stronger than cotton, as strong as jute, and blended well with both and also with hemp, wool and tussore. Pure linseed fibre can be used for manufacturing rope, twine, coarse cloth, etc. and the straw for making paper pulp.

The linseed-flax hybridization work which is in progress at the Indian Agricultural Research Institute has also given encouraging results.

Cordage fibres

Of the cordage fibres, sann-hemp and sisal are the most important commercially. Sann-hemp is extracted from the bark of the stem, while sisal is extracted from the leaf. Sann-hemp fibre is used in making fishing nets as well as maritime cordage because of its resistance to the deleterious action of water.

The earliest work on the improvement of this crop is that by the Howards at the Indian Agricultural Research Institute, who isolated the Jabalpur variety from the seeds collected from various parts of Madhya Pradesh, the fibre of which was found to be superior to that of the local Bihar types. In 1926, the Uttar Pradesh Agricultural Department evolved the improved strain Kanpur-12, which yields higher and gives better quality fibre than the local varieties.

The first important step towards improvement in this crop was taken when the Indian Council of Agricultural Research appointed a specialist to enquire into and report on the condition of the sann-hemp trade with special reference to any possible improvement in the quality of hemp for export. As a result of this enquiry, the Council sanctioned in 1936-37 schemes for the improvement of sann-hemp in Bihar, Bombay, Madhya Pradesh and Madras.

In Bihar, the problem of seed-setting was investigated and a technique was devised by which seed-setting was made possible in bagged plants by introducing bees in them. As a result of the breeding work, an improved variety, B.E. 1 has been evolved which gives a high yield of good quality fibre.

In Bombay, early sowing was found to produce a more vigorous crop than late sowing, but in the former case the quality of fibre was inferior to that in the latter. A wilt-resistant strain, D.IX, was evolved in Poona in 1934-35.

In Madhya Pradesh, the results of the investigations on this crop showed that a seed rate of 80-100 lb. per acre gave higher yields than lower seed rates ; earlier sowings gave higher out-turns of fibre than later sowings ; harvesting at different stages of maturity did not significantly affect the yield ; the earliest sown crop, when harvested at the pod formation stage, gave the highest yield.

In varietal trials in Madras, out of 17 varieties, Kanpur-12 outyielded all the rest. The varieties with medium maturity yielded the best quality and the largest quantity of fibre.

In Uttar Pradesh, the results of the various investigations indicated that the quality of fibre from stalks retted in running water was superior but the yield was slightly lower. Hand-extraction gives more fibre than machine-extraction.

Sisal is used as cordage fibre and has the largest consumption in the world market. In Bombay State in 1952-53, trial of all sisal species and their acclimatization to scarcity conditions was undertaken. In 1953-54, attempts were made to cross *Agave cantala* and *Agave sisalana.* The study of the pollen revealed that the pollen of *Agave sisalana* was not viable, while that of *Agave cantala* gave 2 per cent germination in 7.5 per cent sugar solution. Out of 25 suckers of *Agave sisalana* obtained from Java, which produces the best sisal fibre, 23 have been established.

The work on sisal in India concerns mostly with the extension of *Agave cantala,* which is very abundant throughout India. It could profitably be extended along the river banks, irrigation canals, around the fields and along village lands as a sort of soil-binder.

In Bengal, the experimental plantations of sisal hemp did well and gave a satisfactory out-turn (3.7 per cent of the green leaf weight) of clean, white, strong fibre extracted with the country sugarcane crusher. The experiments on extraction have shown that leaves passed through these crushers and then retted give a workable fibre of good strength. Experiments were also conducted to make this fibre suitable for brush making as for this industry a large quantity of similar fibre is imported annually from outside.

In Assam also the experimental plantation of sisal was found successful.

Other fibres which have possibilities for use as cordage fibres have been obtained from the bark of forest trees *dhamani* (*Grewia tiliaefolia*) and *chir* (*Erinocorpus nimmoni*). Of these, the fibre of *dhamani* was technologically tested and found suitable as cordage fibre.

Brush fibres

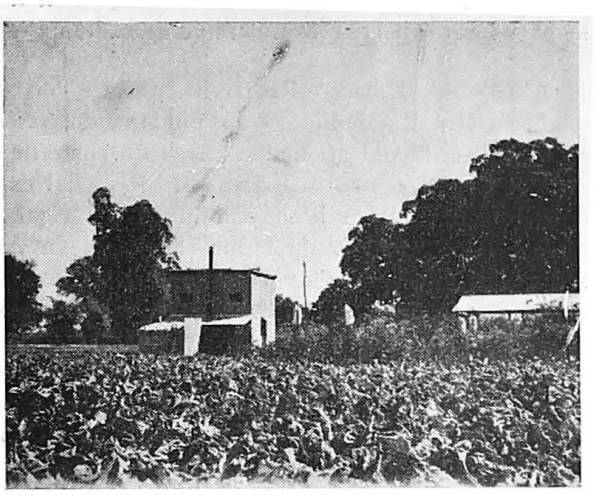
These are mostly obtained from palmyra (*Borassus flabellifer*) and *kittul* (*Caryota urens*) or sago palm. Palmyra fibre is obtained from the base of the leaf stalk. The problem here is exploration of better and less tedious method of extraction.

Kittul or sago palm is grown in the forest areas of Bombay, Madras and Travancore-Cochin. The fibre is obtained from the fibrovascular bundles found at the base of the leaf sheath.

Tobacco

by

B. S. Kadam



Chewing tobacco (in the foreground) at the Botanical Sub-station, Pusa

THERE is a general historical opinion that tobacco was introduced around the year 1605 by the Portuguese somewhere in the Deccan. It is said to have spread from there towards north.

It appears that no organised efforts were made to improve tobacco cultivation until the end of the third decade of the last century. In 1829 experiments on the cultivation of Maryland and Virginia tobaccos were undertaken in the three presidencies of Bombay, Madras and Bengal under the auspices of the Agri-Horticultural Society of India. Similar attempts were continued by the Governments of the various States and the planters in Madras, Bengal and Bombay.

Botanical studies

Not until the establishment of the Imperial (now Indian) Agricultural Research Institute in 1905 at Pusa (Bihar), was systematic work taken up on this important crop. The Howards collected tobacco seeds from all over the country and isolated a number of tobacco types repr-resenting practically all varieties grown in the country. They also made botanical and genetic studies in both *tabacum* and *rustica*. Results of practical utility were the strains of chewing tobacco now known as N.P. 28 and N.P. 63. The former could also be grown as a cigarette type. These two strains gave cured leaf ranging from 1000 to 1200 lb. per acre. They were later replaced by another selection, N.P. 70, from the local variety *Beri* (*Bonhari*). The Institute at Pusa paid considerable attention not only to the development of strains of cigarette tobacco, but also to the method of curing of this variety properly. N.P. 28 was crossed with Adcock, an American type, and two synthetic strains N.P. 142 and N.P. 177, were evolved. These unfortunately proved more susceptible to leaf curl and were later replaced by American varieties, Bonanza and Gold Dollar. The Institute also developed a strain N.P. 18 from *rustica* which gave yields ranging from 1200 to 1600 lb. of cured leaf per acre.

In Bengal a station for wrapper tobacco was established in the year 1906 at Burirhat. Among the wrapper tobacco, the station was able to establish a Sumatra type which ultimately came to be known as Rangpur-Sumatra.

In Bombay considerable amount of plant breeding and some agronomic work was done on *bidi* tobacco at the now defunct agricultural experiment station at Nadiad.

In 1939 Bombay established another *bidi*-cum-cigarette tobacco station at Soundalga in Southern Maharashtra. This station has successfully tackled the problem of growing cigarette tobacco. It has also evolved an improved *bidi* strain S. 20 from the local variety.

Diseases of tobacco

In Madras experimental work on cigarette tobacco was done at the Lam farm, near Guntur, from 1942-47 mainly on diseases of tobacco. It was found that *Orobanche* seed loses its viability after 2½ years. Damping off could be controlled by spraying 1 per cent Bordeaux mixture.

In 1936 a sub-station was established at Guntur for the improvement of Virginia tobacco. One of the important findings of this station was that the soils in Guntur area did not respond to phosphate and potash but application of nitrogen at 20 lb. N. per acre gave significant response. The station also proved that seeds of Virginia tobacco produced in the country were as good as the imported seed. It evolved an improved strain, Amarelo 5, which was found superior

in yield to Harrison Special. But unfortunately it had an undesirable aroma with the result that it had to be withdrawn after considerable spread.

A Central Tobacco Research Institute has been established at Rajahmundry for fundamental research on all tobaccos and applied research on cigarette and *Lanka* tobaccos grown in that area. Regional experimental stations have been established for cigar and cheroot tobaccos at Vedasandur (Madras), for *hookah* and chewing tobaccos at Pusa (Bihar). Recently a station for wrapper tobacco has been started at Dinhata (West Bengal).

Agronomic work

Experiments conducted at Guntur and Rajahmundry have shown that in heavy black soils, cigarette tobacco responds only to nitrogen and not to phosphorous and potash. Since the nitrogen needs of cigarette tobacco are low, the problem of fertilising this tobacco properly is difficult. Recently it has been found that humus requirements of the soils can be adequately met by utilising maize as green manure without excessively increasing the nitrogen in the soil.

Cigarette tobacco is not generally topped but it has been found that judicious topping a few days or a week before the first priming can increase the yield of the crop by 10-12 per cent, without impairing the quality. If one or two light irrigations are given some time in December at an interval of about 15-20 days, the crop benefits considerably, resulting in large increases of yield without reduction in bright grades.

A new variety, Cahtham, which is superior in quality and yields to Harrison Special, has recently been released for field trials. A superior strain from *Lanka* tobacco has also been evolved. A schedule of curing cigarette tobacco has been worked out which increases quality grades and at the same time results in saving of fuel.

Under Anand conditions it has been found that in light soils *bidi* tobacco responds profitably to doses of nitrogen even higher than 120 lb. per acre in the form of oil cake. It has been observed that stem-dust, a waste product of *bidi* tobacco processing factories, can be utilised profitably for manuring *bidi* tobacco.

In the cheroot and chewing areas in Madras a dose of farmyard manure of 20 cart loads supplemented by 90 lb. nitrogen, either as sulphate of ammonia or as groundnut cake or supplied equally from both the sources, increases the yield.

For *hookah* tobacco in the Punjab a similar manurial schedule, but with split application before and after transplanting, has proved profitable.

The Tobacco Grading Scheme, under the technica supervision of the Marketing Adviser to the Govern ment of India, has been successful in standardising the quality of Indian tobaccos in foreign markets and establishing high reputation for our flue-cured tobacco.

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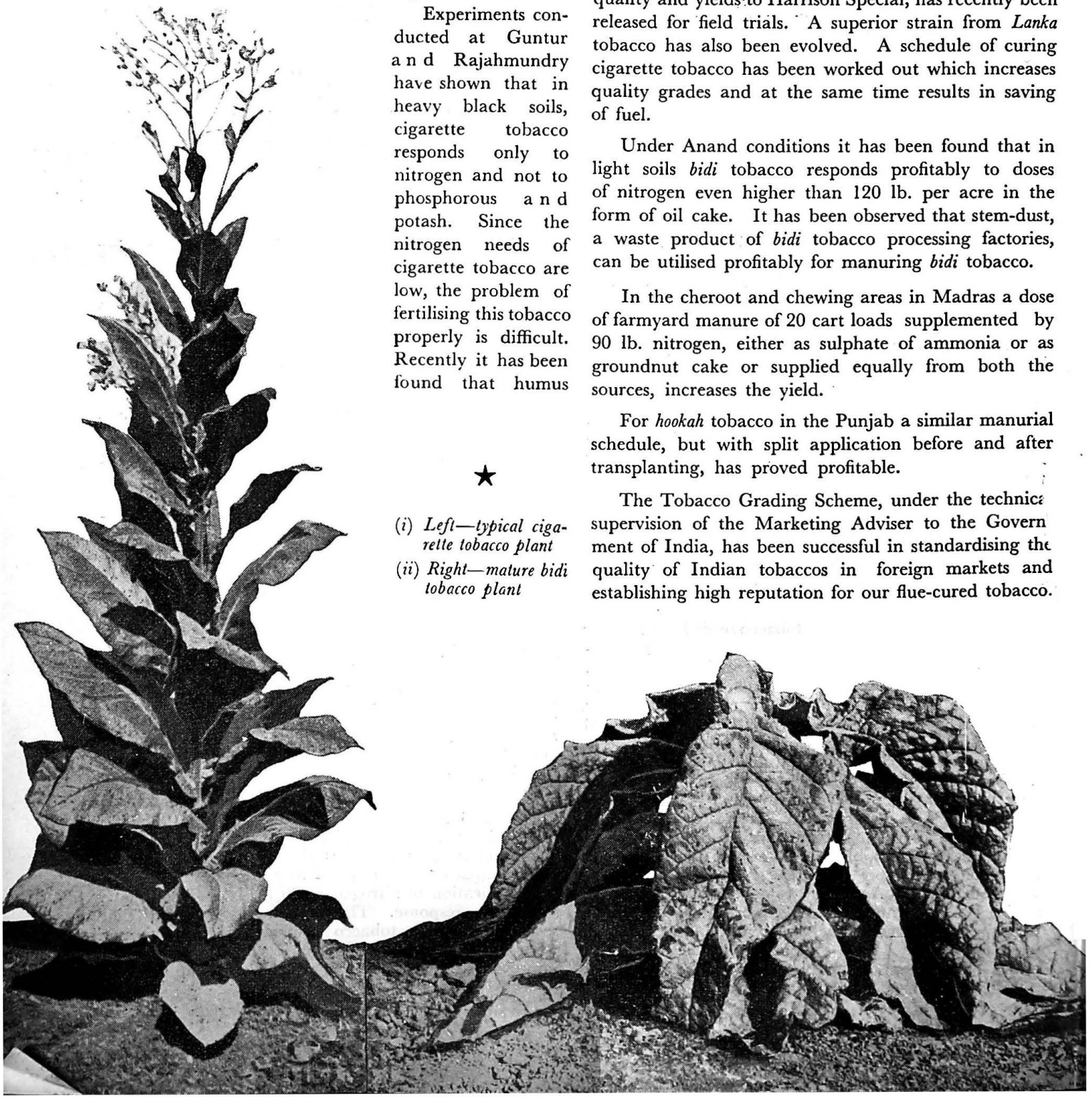
(*i*) *Left—typical cigarette tobacco plant*

(*ii*) *Right—mature bidi tobacco plant*



Soils Manures & Fertilisers

by

S. P. Raychaudhuri

R. D. Asana

J. A. Daji

A compost trench on the farm

THE beginning of scientific investigations on Indian soils and indigenous manures and fertilisers may be traced back to Leather in 1905.

Leather divided India into four major soil classes, *viz.*, alluvial, red, laterite and black soil.

A survey and classification of black soil areas under canal irrigation in the Bombay-Deccan on the basis of morphological features and chemical composition of the soil profile was made at the Padegaon Research Station in the Bombay State. Soil survey for irrigation purposes was carried out in the Nizam Sagar Project area in Hyderabad and the Tungabhadra Project area in Madras.

In 1937 a study of Indian soils in greater detail was undertaken at the Indian Agricultural Research Institute and a soil map of India in which the soils of India, depending on their colour and climatic conditions, were grouped, was printed in 1943. The final report of the All-India Soil Survey Scheme (1953), published by the Indian Council of Agricultural Research, includes a comprehensive account of soils and related topics and also soil maps for different States and a modified soil map of India based on recent data.

Soil and water conservation

Annual loss of soil by erosion and run-off have been estimated at the Soil Conservation Experimental Station at Sholapur in Bombay, at Hagari and Nanjanad in Madras and at Vishvabharati Institute at Shantiniketan, where investigations have been carried out on soil erosion and soil loss under conditions obtaining in those areas. The electro-chemical and viscous properties of clay and clay minerals were studied in some detail at the Chemical Laboratories of the Calcutta University, and it was established that these are important methods for the identification of clay and clay minerals. The work on clay minerals at the Indian Agricultural Research Institute has shown that the reflection spectra of ignited soils can be used to determine the dominant mineral of the clays.

Physical properties of soils

The work at the Punjab University has shown that the effectiveness of mulches depended on the initial moisture content and texture of the soil.

At the Indian Agricultural Research Institute it has been observed that the correlation co-efficients were different in different groups of Indian soils.

Saline and alkaline soils

An alkaline soil profile in the Punjab and Uttar Pradesh is often characterised by a layer of accumulation of soluble salts and layer of accumulation of calcium carbonate occurring in the form of nodules. The use of molasses and gypsum have been found useful for the reclamation of alkaline soils in the dry tracts of North India.

Nitrogen

The low nitrogen status of Indian soils was recognised as early as in 1889 by Voelkar. The 30 years observations of drainage experiments at Pusa showed that Indian soils might lose about 100 lb. of nitrogen per acre per year through drainage and through crops, and the effects of growing crops was to reduce the loss of nitrogen through drainage.

It has been reported by some workers that blue green algae in paddy fields fixed considerable quantities of nitrogen.

Phosphorus

That phosphate deficiency was also quite widespread in Indian soils was suggested as early as in 1914. The work at the Indian Agricultural Research Institute on the estimation of total and available phosphate contents of a large number of cultivated and virgin soils from different parts of India showed that fixation of phosphates in soil increased with the percentages of sesquioxides in the hydrochloric acid extracts of soil, their clay contents and base exchange capacities.

Potash

Numerous experiments carried out in India showed that Indian soils did not respond to application of potash fertilisers.

Micro-nutrients

The work on micro-nutrients is comparatively recent in India. The work was mainly concerned with the die-back disease of citrus fruits. Promising results have been obtained by sprinkling zinc and manganese salts in citrus orchards in Coorg. Experiments in Bombay showed that the application of zinc increased very considerably the yield of groundnuts.

Microbiology

A method of determining manurial requirements of soil from bacterial activities as measured by the evolution of CO_2 from soils under different manurial treatments was developed at the Indian Agricultural Research Institute. It was shown that a defection nitrification belt in India runs from east to west across the middle of the country.

A process for utilisation of cow dung both as fuel and as manure, both of which are in great demand throughout the country, was achieved through anaerobic fermentation of cow dung.

Fertilisers and manures

A critical study of the practice of green manuring in India has revealed that green manuring, though beneficial, is liable to be uneconomical. Use of wild legumes as green manure crops has recently been studied at the Indian Agricultural Research Institute.

It has been found that in composting, better results were obtained when the fresh refuse organic matter was turned in the soil than when it was composted outside and put in the soil.

Indian soils invariably respond to the application of nitrogenous manures whenever a cereal crop is grown, and that most of the common cultivated legumes benefitted by application of phosphatic fertilisers.

Paucity of organic matter in Indian soils, and the necessity of the same in maintenance of proper soil structure would suggest that the manurial applications should be mixtures of both organic and inorganic fractions for their best utilisation by crops.

Dry farming

by

J. K. Basu

DRY farming or growing of crops in regions of low, uncertain and variable rainfall is considered one of the major problems of agriculture. The rapid increase in population has necessitated intensification of agriculture in the arid and semi-arid regions of the world which have roughly been estimated at 65 per cent of earth's land surface. The problem is complicated by the fact that the variability of rainfall increases with diminishing precipitation, thus increasing the difficulties of growing a normal crop in such regions.

It is necessary to define the areas where dry farming is practised. Dry farming tracts have been defined by American workers as areas receiving less than 20 inches of rainfall, but under tropical conditions the limit of rainfall should be raised to compensate for the loss of moisture by evaporation. For example, in the dry farming regions in the U.S.A., Canada or Australia, with mean annual temperatures of 40°-60°F., one can grow a fairly good crop with even 10-15 inches of annual rainfall. In India, where the mean annual temperature of about 80° F. is experienced in the " problem areas ", the equivalent rainfall will be of the order of 25-45 inches. So far no accurate survey has been carried out of the dry farming areas in India, but it may be fairly safe to estimate it as one-third of the total arable land.

What is dry farming ? It is an improved system of cultivation in which the maximum amount of moisture is conserved in the soil from low and untimely rainfall for the production of optimum quantities of crops on an economic and sustained basis. Conservation of soil and water is an inter-related problem, and where the soil conservation methods are sound, these help in the conservation of optimum amounts of water for plant growth. Broadly speaking, the following measures constitute dry farming system of cultivation :

(1) Selection of proper land for different dry crops.

(2) Contour bunding to prevent rain water run-off and to check soil erosion.

(3) Contour cultivation to absorb rain water, reduce evaporation and control weed growth.

(4) Use of seed of improved crops.

(5) Adoption of a lower seed rate and wider spacing of crops.

(6) Manuring to improve soil structure and supply plant food.

(7) Practising contour strip-cropping, *i.e.*, growing of erosion-resisting crops (pulses and legumes) and erosion-permitting crops (cereals) in alternate strips to check run-off and soil loss.

(8) Fallowing and rotating crops, *e.g.*, growing of cereal crops and legumes in alternate years to increase soil moisture and fertility.

Although the methods of dry farming indicated above are known, it is necessary to work out the details of the various aspects of this type of farming to suit different conditions of soil, climate and slope. Only a brief review of the work done so far in India has been given here. It may not be out of place to mention that amongst the different States of the Union, intensive research on dry farming and soil conservation has been carried out at Sholapur and Bijapur in Bombay State, Hagari in Madras, Raichur in Hyderabad and Rohtak in the Punjab, under a co-ordinated scheme for dry farming research sanctioned by the Indian Council of Agricultural Research during the years 1933-1943. In Bombay State, work has been continued even after the termination of the scheme and valuable data have been collected. Similar work has also been undertaken at Visva-Bharati in West Bengal, and in Saurashtra and Vindhya Pradesh.

Research work in Bombay

A systematic and scientific approach to the problem of dry farming was made in the Bombay State as early

as 1926. A good deal of work was done at Manjri on some aspects of soil erosion and run-off, and a system of dry farming suitable for the scarcity tract was evolved. Later in 1934, a Dry Farming Research Station was established at Sholapur. A sub-station was also established at Bijapur. The work carried out during the period 1934-44 is outlined below:

The soil. An intensive study of the soils of the Sholapur and Ahmednagar districts has shown that these soils can be classified into three distinct types suitable for different cropping systems. On the basis of soil depth, they may be classified into deep, medium deep and shallow soils. The deep soils of the Bijapur district were further classified into deep black, medium black and limy or *kankar* on the basis of colour and lime content.

It was observed from the run-off studies that surface treatment of scooping and listing resulted in the reduction of run-off when compared to keeping the land bare fallow. The soil removed from a *jowar* plot by erosion was found, on an average, to be 37 tons per acre, while a plot sown with groundnut lost less than two tons per acre. It was also estimated that with the removal of the eroded soil, the average loss of nitrogen per acre was equivalent to the quantities removed by 10 *jowar* crops.

The crop. A study of the physiology of the *jowar* plant has revealed that 400 lb. of water is required to produce one pound of dry matter, and accordingly a rainfall of 2-3 inches is necessary for maturing an average crop of *jowar* (*i.e.*, less than half a ton of dry matter). It follows that of the total rainfall of 25 inches, only about 8-10 per cent is required to mature a *jowar* crop. Further, it was shown that a manured field (with farmyard manure) requires much less water to mature a *jowar* crop with the same weight of dry matter of grain and straw than a field not so manured.

Field experiments. These experiments proved the efficacy of bunding in increasing the yield of dry crops. Ploughing every year or in alternate years was not found to be superior to harrowing, while harrowing and inter-culturing definitely proved more beneficial in increasing the moisture content and yields of crops. A seed rate of 4 lb. per acre with a spacing of rows 18 inches apart was found to give the optimum out-turn of *jowar*.

Later experiments conducted during 1944 to 1954 have indicated that ploughing may be done once in six years without any detriment to crop yield. Three harrowings and one inter-culturing appear to give the highest yield of *jowar* crop. Ten pounds of nitrogen applied as groundnut cake in the rows gives an economic out-turn of *jowar* crop in normal years. A dose of 4 lb. boron and 6 lb. of manganese increases the yield of groundnut by 25-30 per cent. *Jowar* rotated with groundnut can give about 40-50 per cent higher yield when compared to continuous cropping of *jowar*. The yield is further increased when phosphate (at the rate of 10 lb. P_2O_5 per acre) is applied to groundnut.

As a result of the research work referred to above, the Bombay system of dry farming has been evolved which is capable of increasing the yield of *rabi jowar* by about 2½ times as compared to the yield obtained by the cultivators' method.

Contour strip cropping. As a result of intensive investigations, a system of cropping has been evolved to suit the undulating lands of the Deccan Plateau where erosion of soil is severe, particularly when the lands are not contour-bunded. According to this system, narrow strips of erosion-resisting crops, *i.e.*, cover crops are grown alternately with strips of erosion-permitting crops, *i.e.*, cereals, etc. The results of experiments on strip-cropping show that *matki* (*Phaseolus aconitifolium*), *kulthi* or *hulga* (*Dolichos biflorus*) groundnut and *mug* (*Phaseolus radiatus*) produce excellent canopies at critical periods of soil erosion, and that widths of 18 ft. or more of the erosion-resisting strips of cover crops are very effective in the prevention of rain water run-off and the consequent washing away of soil. The following recommendations have been made for lands up to 3 per cent slope:

(*a*) A width of 24 ft. of erosion-resisting crops (*e.g.*, groundnut, *hulga*, etc.) is alternated with a width of 72 ft. of erosion-permitting cereals (*e.g.*, *bajri* or *jowar*).

(*b*) Increased seed rates of erosion-resisting crops are used. Twice the normal seed rates of *matki*, *hulga*, *mug*, etc. are recommended.

(*c*) Strips of erosion-resisting crops are rotated with strip of erosion-permitting crops annually so that in four years the entire field is completely covered.

Erosion surveys. A soil erosion survey of about 80,000 acres in 43 randomely selected catchments in

the Deccan and Karnatak has revealed that about 57 per cent of the land is slightly or moderately eroded, while 32 per cent of the land is so badly eroded that it will hardly support any crop growth. If this sample survey is a fair estimate of the pattern of erosion in the areas surveyed, the situation is very serious and calls for immediate measures to check further loss of soil by erosion.

Bunding. The Bombay Government has been conscious of the seriousness of the situation and has been actively engaged in anti-erosion measures since 1943. About 12 lakh acres have been contour-bunded so far.

Research work in Madras

Although the Agricultural Research Station at Hagari was opened in 1906, a full-fledged scheme for dry farming research was launched only in 1934 with the assistance of the Indian Council of Agricultural Research.

Hagari is a typical dry farming area of the Southern Peninsula with an annual rainfall of 20 inches and is located in the black soil region. Investigations were conducted till 1943 and the salient features of these studies are given below.

In the run-off plot experiments it has been found that about 20 per cent of the total rainfall is lost by surface run-off and about 6.4 tons of soil are lost by erosion. The treatment by scooping reduces the run-off by about 50 per cent, while cropping with groundnut is helpful in reducing soil erosion.

An improved strain H-1 of *jowar* was evolved, and it was found to give better yields than the local strains. This strain was found to put forth a larger number of roots in early stages as compared to local types, and hence it was more drought-resistant.

Soil moisture studies revealed that there was an increase in moisture content to the extent of 20-25 per cent in the bunded plots as compared with unbunded plots, increase in crop yields being 24 per cent and 14 per cent for *jowar* and cotton respectively.

A wider spacing of 18 inches in the case of *jowar* (*Sorghum* sp.) and of 36 inches in cotton was found to be suitable as compared with narrower spacing followed by the cultivators. The effect of fallowing after cotton as well as *jowar* is significantly better than continuous cropping, percentage increases in yield being 50 and 56 respectively.

Research work in Hyderabad

A Dry Farming Experimental Station was started in the year 1933 at Raichur and continued up to 1943. A summary of the results obtained is given below.

Varietal trials conducted with *jowar* for a number of years indicated the superiority of M-35-1 as compared to the local or N.D. 9. Experiments on the effect of fallowing with *jowar* indicated that there was a significant increase of 81 per cent in the yield of grain and of 85 per cent in straw as compared with continuous *jowar* cropping. Experiments on bunding were carried out for three years in succession which indicated the potency of increasing the grain and fodder yield of *jowar* to the extent of 22 and 13 per cent respectively, on account of bunding alone.

Research work in Punjab

The Dry Farming Research Station at Rohtak in the heart of the dry region of North India was started simultaneously with the other three stations in South India and the more important results are described below.

Tillage experiments carried out on alluvial soils indicated that strirring the soil with a *desi* plough increased the yield of crop significantly as compared with the weeded and unstirred plot, the increase being 65 per cent.

Water requirement experiments conducted on *bajri* (*Pennisetum typhoideum*) for four years indicated that the seasonal influence was of more importance than the varietal difference. Root studies on *bajri* showed that there was more of vertical penetration than laterial expansion, thus showing suitability of *bajri* for dry farming.

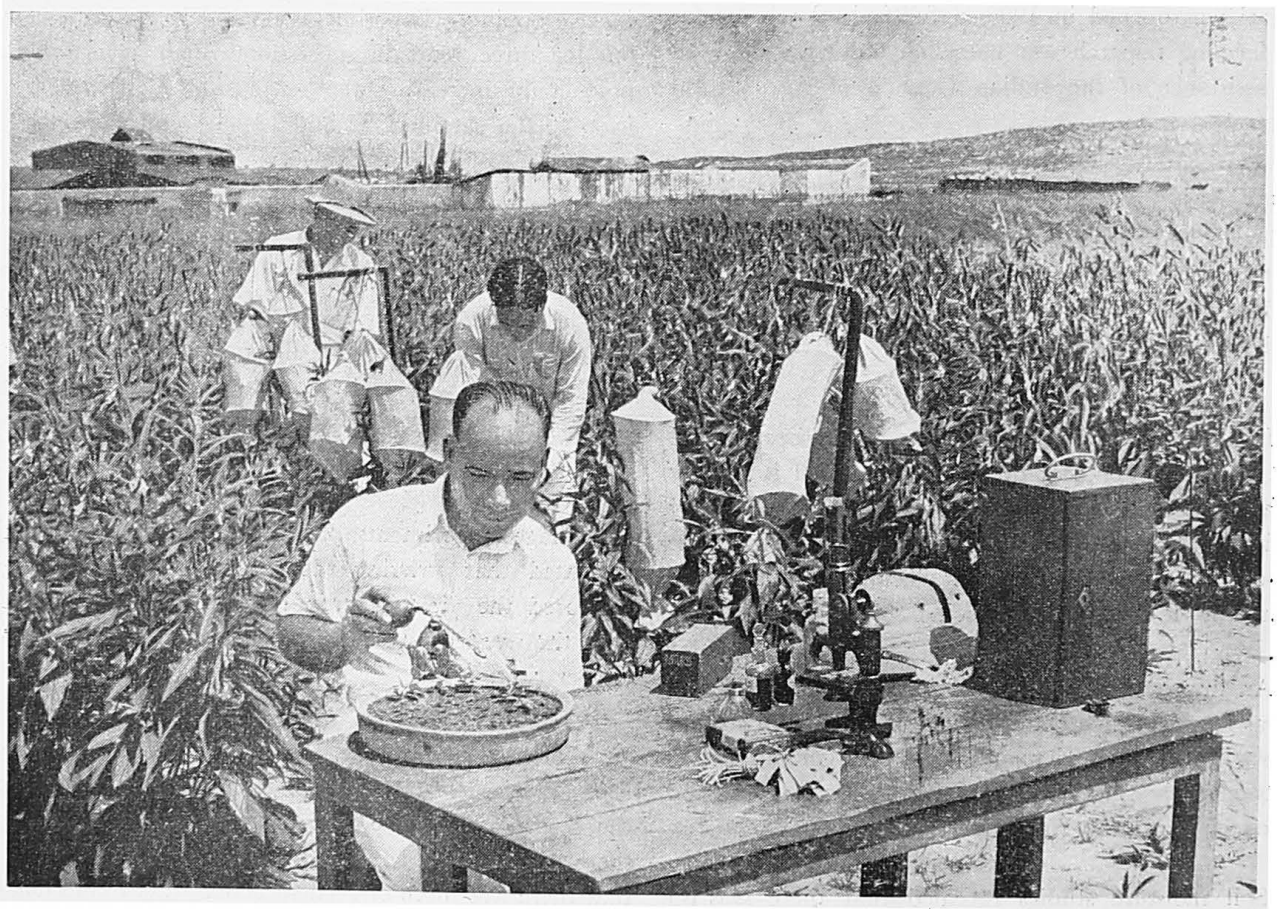
It was observed that the land under the dry farming system of cultivation conserved about 50 per cent more moisture than that under the cultivators' method of farming.

Research work in West Bengal

Soil conservation research was carried out at Vishva-Bharati, Santiniketan, from 1944 to 1952 on a highly eroded lateritic soil. Run-off studies have indicated the dangers of keeping the land bare, *i.e.*, without any vegetative cover. Grass has proved to be the best cover from the point of view of checking run-off and soil loss. Groundnut proved a successful erosion-resisting crop in strip-cropping experiments.

Work in other States

About 6,000 acres of land in Saurashtra have been put under bunds on the model of bunds constructed in Bombay State. In Vindhya Pradesh, about 25,000 acres have been brought under improved methods of dry farming.



Scientists at work in the Indian Agricultural Research Institute

Agronomy

by

T. J. Mirchandani
R. J. Kalamkar
R. D. Rege

Crop trials at Government Agricultural Farm, Jullundur

THE salient points relating to results of agronomical research on various crops are indicated below.

Paddy

Application of ammonium sulphate to paddy at the rate of 20-40 lb. nitrogen per acre has given profitable responses, and increases in yields of the order of 20-60 per cent have generally been obtained.

As regards green manuring an application of 30-40 lb. of nitrogen in the form of green leaves can be expected to increase the yield by 20-30 per cent. Heavy doses of 60-80 lb. nitrogen have given in certain areas even 100 per cent increase in yields.

Extensive experiments with sodium nitrate have proved its harmful effects on the paddy crop. Experiment with calcium cynamide, ammonium nitrate and potassium nitrate show that they are not as good as ammonium sulphate.

Organic nitrogen in the form of oil cakes has also been found to increase the yields considerably. Cakes are as good as ammonium sulphate.

In regard to the application of phosphatic manures, the general results have been that there is either no response, or where some response has been observed, increase in yield is only of the order of 8-10 per cent, though the rice soils in many tracts are deficient in phosphorus.

Experiments with paddy have shown that the need for supplying potash to this crop is comparatively unimportant.

It appears that paddy gives the highest response to nitrogenous manures and gives an extra yied of 10-20 lb. of paddy for every 1 lb. of nitrogen added to the soil per acre. Heavy manuring of nursery has been found to be ineffective in increasing the final yields of the crop. Results of rotation experiments conducted in Uttar Pradesh have shown the beneficial effects of growing gram on the yield of rice.

Wheat

In irrigated trials, wheat showed a universal response to nitrogenous manuring. In the black soil tracts, the average response was 7·8 lb. of grain per lb. N as sulphate of ammonia. Average dose of nitrogen was found to be 15 lb. N per acre. Different oil cakes and green manures were other sources of organic nitrogen which showed good results. In Madhya Pradesh, phosphatic manuring produced good results.

In unirrigated trials, the average dose was only 8·6 lb. N. The response to organic nitrogen was positive but not very high. Results with green manuring were not uniform. Phosphate did not produce tangible results. A combination of nitrogen and phosphorus was better.

In Gangetic alluvium, the results of nitrogenous manures were similar to those in black soil areas, ex-

cepting that in this tract the average dose of nitrogen to be applied per acre was 20-30 lb. N.

The responses to ammonium sulphate were somewhat more uniform than those to sodium nitrate. Urea, too, did not give very satisfactory results when compared with ammonium sulphate. Green manuring under irrigated conditions or assured rainfall was highly beneficial to the wheat crop everywhere. Drilling the fertiliser with seed gave a better response than that obtained by broadcasting it.

Irrigation trials showed increasing yields with more irrigations but the largest increase was observed when two waterings were given instead of one.

Sorghum

The response to the application of nitrogen was marked on better land. Twenty pounds of nitrogen gave an average response of 7·9 lb. of *jowar* grain per lb. N and this seemed to be the optimum dose. An application of nitrogen at the sowing time is preferable to later applications.

Other sources of inorganic nitrogen were generally less efficient than sulphate of ammonia. Oil cakes gave increases of 3-6 lb. of grain per lb. N for doses equivalent to 20-30 lb. nitrogen.

Maize

In Bihar there was a consistent response to nitrogen applied as ammonium sulphate, the average increase being 11·8 lb. of grain for one pound of N. Manuring at the earthing up time was definitely more effective than at sowing. Poudrette, and cow and horse dung also proved effective in Uttar Pradesh. The most suitable dose of nitrogen for maize was found to be 50 lb. per acre.

Sugarcane

Nitrogenous manuring has been found to be a definite necessity for sugarcane throughout India, while in case of phosphatic and potassic fertilisers, distinct advantages have been secured only in a few cases. On the other hand, there are some instances showing that potassic manuring has actually depressed yields.

As regards nitrogen, experimental evidence indicates that its optimum dosage is much lower in Gangetic alluvium than in Peninsular India. The dose of nitrogen in the former case ranges from 150 to 200 lb. of N per acre, while in the latter case, it is between 200 and 400 lb. of N per acre.

In the northern belt farmyard manure has been chiefly valued as a nitrogen supplier. Experimental work has, however, suggested that it is inferior to oil cakes or sulphate of ammonia.

The favourable effect of the application of molasses, two months before planting, on increasing sugarcane yields has been experimentally proved in Uttar Pradesh, a dosage of 180 maunds per acre being found to be the optimum.

According to the work done at Padegaon, higher watering requires heavier manuring, and on the whole 95 acre inches of water inclusive of rainfall, is found to

Experimental nursery at the Central Rice Research Institute, Cuttack

be the minimum water requirement of the cane crop within a period of 12 months.

Unlike other crops, sugarcane responds to deep cultivation and gives economical returns.

As regards ratooning, it has been found that yields of late ratoons are less than plant crops under the same cultural and manurial experiments.

Rotation experiments showed that the tonnage yields were directly linked with the better fertility status of the soil, induced by growing *patada shevra* (*Desmodium diffusum*) and sann-hemp or a mixed crop of pigeon pea and groundnut.

Potato

Potato crop responds very well to manuring. Provided irrigation supplies are assured, heavy manuring of the crop always yields substantial returns. Two hundred pounds of niciphos and 200 lb. of sulphate of ammonia gave the highest yield in Assam. In United Province, 100 lb. of N in the form of cakes produced outstanding results. In Bihar and Orissa 240 lb. of ammonium sulphate on a basal application of farmyard manure at 200 maunds per acre produced significant increases. Complete fertilisers (75 lb. N, 35 lb. P_2O_5 and 75 lb. K_2O) have been found to increase the yields by 74 per cent. As regards the placement of fertiliser, fertiliser mixtures applied below the seed gave the highest yield.

In the plains, it has been found that whole tubers used for planting during October and November gave good results. Cut seeds can safely be used, however, under fairly cool conditions. Sprouted seed tubers gave yields better than unsprouted seed tubers.

In Uttar Pradesh from the last week of October to the first week of November is the optimum period for planting. The most favourable time for planting in the hills depends primarily on altitude. Generally, the higher the altitude, the later is the planting time between February and April. Delay in planting after April lowers the yields considerably.

With varieties like *Phulwa*, the best spacings when using the recommended seed size, is 2 feet between rows and 9 inches between tubers. The general principle is that the larger the tuber, the wider the spacing.

Profuse flowering in potato has an adverse effect on the final yields.

Cotton

Both under irrigated and rain-fed conditions, cotton shows a universal response to nitrogenous fertilisers especially ammonium sulphate and organic manures like oil cakes. Of the three nutrients, only nitrogen appears to be essential.

In black soils, groundnut cake seemed to surpass ammonium sulphate in its value as fertiliser. Besides groundnut cake, *toria* cake and *neem* cake produced good results. The dosage of nitrogen differs from tract to tract.

The proper time for the application of these fertilisers was to apply half at the time of sowing and half just before flowering.

In Berar, a spacing of 15 inches from row to row and seven inches between plants in the row gave the highest yield. For bushy varieties like 4F, the recommendations are 3-3⅓ feet distance between rows and 1½ feet within plants in the row. In Gujerat the recommended spacing is 3 ft. × 2 ft.

The optimum time of cotton sowing differs from tract to tract. In North India, berseem, gram and *senji* have been found to be useful rotation crops, while in the South, groundnut and pigeon peas have given good results, groundnut being the best.

Oilseeds

Groundnut has been found to respond uniformly to phosphatic fertilisers at 30-40 lb. P_2O_5 per acre. The response to combination of N and P_2O_5 was considerable; it was more effective when the P_2O_5 supplement was in a larger proportion than nitrogen. In spacing trials in Madras, a spacing of 6 × 6 inches was found to be the best.

Linseed did not respond to manurial treatments. Irrigation was beneficial.

Mustard and rape did not give significant response to nitrogen application; phosphorus application proved beneficial.

Pulses

Since all pulses are leguminous crops, application of phosphorus brought about good results, when compared with the application of nitrogen. The average increase in the case of gram was 6.0 lb. of gram per pound P_2O_5. Superphosphate increased the yield at the rate of 7.0 lb.-9.4 lb. per P_2O_5. At many places there was no response.

The results of mixed cropping experiments revealed that pigeon pea mixed with a spreading variety of groundnut gave the maximum out-turn per acre. To avoid wilt, gram should not be sown mixed with another crop.

Tobacco

A basal dressing of mineral manure was beneficial over no basal dressing as regards green leaf yield. N, K, NP, and NPK gave a longer period of glow with a basal dressing than without a basal dressing.

Mycology & plant pathology

by

R. S. Vasudeva

Leaf-roll of potato

YIELDS of crops in India are lower than those in other countries even under normal conditions. Diseases are one of the important factors which depress yields. It is generally believed that the yields per acre in India can be pushed up by about 10 per cent by preventing losses due to diseases.

Fungus flora

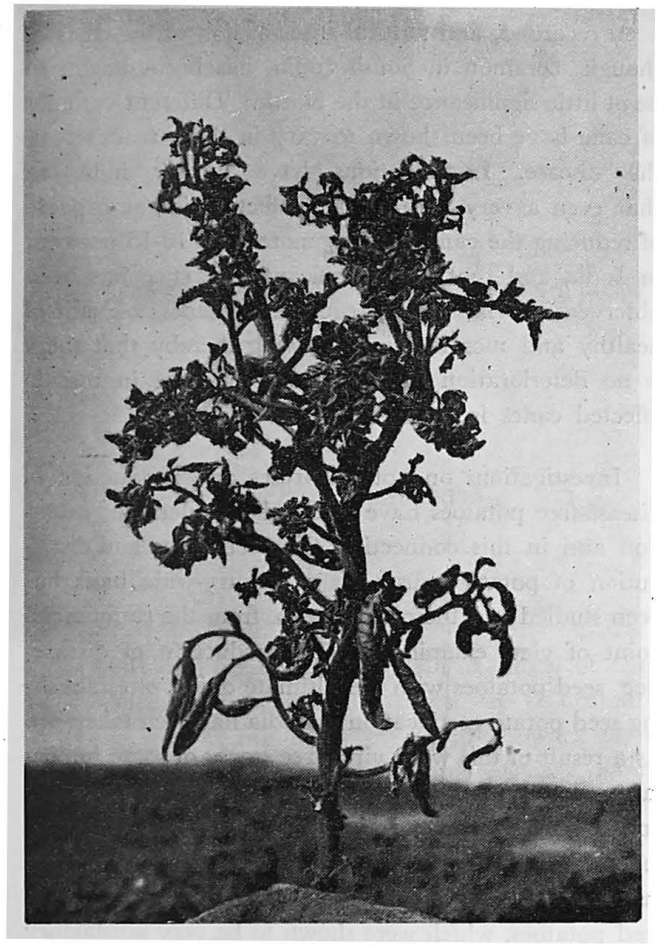
The Indian Council of Agricultural Research published two important monographs on the Fungi of India which formed the basis of research work on crop diseases in this country. Important pathogens belonging to *Phycomycetes* such as *Phytophthora* sp., *Pythium* spp., *Sclerospora* spp., *Albugo* spp., *Synchytrium* spp., *Peronospora* spp., etc. have been investigated. Toxonomic studies on *Ustilaginales* and *Uredinales* have received much attention. *Polyporaceae* occuring in Bengal, Assam and the eastern Himalayas have also been studied. The fungus flora of Madras, Mysore, Bombay and certain other places in Uttar Pradesh have been investigated and a number of new species and new genera have been added. The work on the genus *Helminthosporium* in India in this connection requires special mention. Toxonomic work on fungi belonging to the genera *Fusarium, Phyllosticta, Meliola, Cercospora, Sphaceloma, Aspergillus, Colletotrichum, Pestalotia, Monochaetia,* etc. have been worked out in greater details. The work relating to the maintenance of cultures of fungi and bacteria as also of yeast for plant pathological investigations, medical investigations and industry has received encouragement.

Diseases of cereals

In the Indian Union, the annual loss in wheat due to rust damage has been estimated at Rs. 49 million but in years of epidemic it may assume more serious proportions in certain areas. Wheat suffers from all the three rusts—black, yellow and brown. The yellow rust is restricted to the northern parts of the country including the Indo-Gangetic plain, though it is not altogether absent from South India. Wheat varieties resistant to individual rusts have been evolved, and efforts have also been successful in evolving a variety resistant to all the three rusts and their races.

Against loose-smut of wheat, which is also of considerable importance, wheat varieties such as N.P.114, 120, 121, 163-3 and 163-4 have shown high resistance. The old hot water treatment has been replaced by the solar heat treatment which requires no complicated apparatus and is one of the cheapest known methods for the control of the disease. This method has also been found effective in the control of grain smut of *jowar* and loose-smut of barley.

A bacterial disease of wheat, which is assuming serious proportions, has been studied and the method of control, which consists in the separation of galls by floatation method, has been recommended.



Leaf-curl of tomato

The covered smut of barley has been shown to be effectively controlled by fungicidal seed dressing, and dry formalin method for the control of oat smut has been recommended.

Foot-rot in wheat, barley and paddy has been effectively controlled by the use of fungicidal seed dressing.

Primary infection by *Helminthosporium* in rice has also been shown to be kept under check by fungicidal seed treatment. Rice varieties Co. 25 and Co. 26 resistant to blast, which is the most serious disease of this crop, have been evolved.

Wilt disease

It has been shown that gram wilt can be controlled by adjustment of sowing time. Varieties of crops such as pigeon-pea and cotton resistant to wilts have been evolved by the co-operative efforts of plant pathologists and botanists.

Root-rot of cotton

Root-rot of cotton has been shown to be caused by soil-borne fungi which become active under high temperatures. A novel method for the control of the disease by mixed cropping with *Phaseolus aconitifolius* has been evolved and recommended. The disease can also be kept under control by adjustment of sowing time in areas where it fits in with agricultural practices. Black-arm disease of cotton has been investigated and it has been shown that varieties vary in their susceptibility to the disease.

Linseed varieties resistant to all the four Indian races of linseed rust have been evolved.

Late blight of potato has been shown to be effectively controlled by certain fungicidal sprays.

The efficacy of seed dressing fungicides as also those of sprays against different seed and air-borne diseases have been determined.

Sugarcane diseases

Out of 55 diseases recorded on sugarcane, 33 diseases are known to occur in India. The life history of the red-rot organism which is responsible for heavy losses to the crop has been studied and schedules for control of this disease as also the smut of sugarcane have been evolved.

Tea and coffee

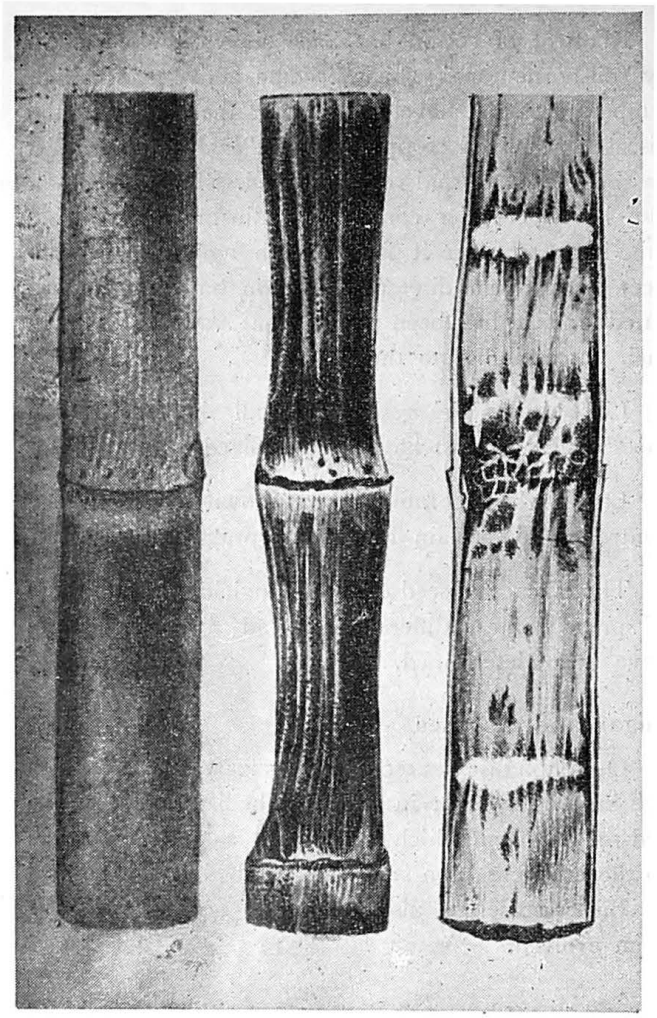
Blister blight of tea which is serious in the north-east and is assuming serious proportions in the southern regions has been studied and methods of control of the disease have been recommended. The rust on coffee has received due attention and varieties resistant to this rust have been made available. Spraying to keep the disease under check has also been recommended under certain environmental conditions.

Fruit disease

Diseases of fruits such as those of citrus, mango and the hill fruits have received due attention as also diseases of spices and certain other minor crops. The bud-rot of palms has been investigated, and diseases of coconut palm which are responsible for serious losses in the south have been under investigation.

Virus research

Virus research relating to plants, which in the earlier years did not receive adequate attention, has now been accepted as an integral part of plant pathological



Red-rot of sugarcane

work. The spike disease of sandal had, however, been studied earlier in Mysore State mostly from physiological and biochemical points of view.

Aphis maidis, the vector of sugarcane mosaic virus, is known to occur all over the country, but the conditions for the transmission of the virus are not favourable in all the sugarcane growing areas. Three strains of the virus, differing mainly in physical properties, have been recorded, and natural transmission of the disease, though common in South India, has been shown to be of little significance in the North. Different varieties of cane have been shown to vary in their reaction to the disease. Investigations have further indicated that even a very high mosaic infection is not capable of reducing the cane yield by more than 10-15 per cent in India and that no significant difference has been observed in brix, purity, sucrose or glucose content of healthy and mosaic juice, showing thereby that there is no deterioration in the quality of juice in mosaic affected canes in India.

Investigations on potato viruses and production of disease-free potatoes have received considerable attention and in this connection the occurrence and distribution of potato viruses on a country-wide basis has been studied and their importance from the commercial point of view examined. The production of disease-free seed potatoes with the ultimate object of establishing seed potato certification in India has been taken up. As a result of this work virus-free stocks of some important commerical varieties, *e.g.*, *Darjeeling Red Round* and *Up-to-date* and certain potato hybrids have been made available. As an immediate measure during the last war to step up potato production, partly disease-free seed potatoes, which were shown to be very satisfactory both from the point of view of disease incidence and out-turn, were made available in large quantities to the growers. A number of important virus diseases of potato were described during the period.

The White-fly (*Bemisia tabaci* Gen.) has been established to be a potent vector of certain important virus diseases, *e.g.*, tomato and tobacco leaf-curl, *Bhindi* yellow vein mosaic. Banana aphis, *Pentalonia nigronervosa* Coq., has been established to be the vector of *Katti* disease of cardamom. Methods of control of *Katti* disease of cardamom, which is an important cash crop, have been devised and applied in North Kanara.

Entomology

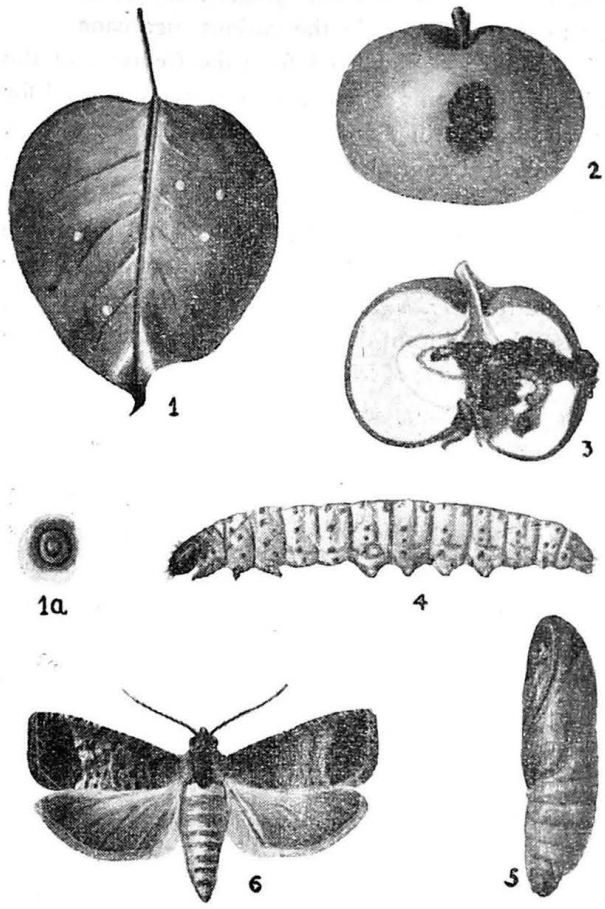
by

E. S. Narayanan

SINCE its inception, the Indian Council of Agricultural Research has taken up co-ordination as well as initiation of research work on entomology, both fundamental and applied, on a planned basis. The Council initiated and financed research not only in various States but also in different universities of the country.

Pests of cotton

As cotton is one of the chief cash crops, the Council took interest in the control of its pests. The work on the spotted bollworm of cotton was done at Surat. The main conclusions of the investigations carried out at this centre are that the pest does not hibernate and that it is carried on from one season to another by means of alternate host plants and by adventitious shoots that arise from the stubbles left after the harvest. A plant puller devised for the removal of these stubbles left in the field has become popular with the peasantry all over Gujerat. Uttar Pradesh has done excellent work on the control of pink bollworm, and the heat treatment of cotton seed is widely practised wherever cotton is grown. Much work has been done on the cotton white fly, *Bemisia gossypiperda*, which is a serious pest of cotton in Punjab. Irrigation experiments showed that the attack is inversely proportional to the quantity of water supplied to the crop. Plants treated with nitrogenous manure showed comparatively less infection. The bionomics of the cotton stem weevil (*Pempheres affinis*), a serious pest of cotton in India, has been studied in detail at Coimbatore.



Codling moth, Carpoeapsa pomonella L

1. *Egg laid on leaf*
   1a *An enlarged egg*
2. *Apple fruit infested by the larva, showing the exist hole*
3. *A section of damaged fruit showing the larvae tunnel. The full-grown larva is also seen near the tunnel*
4. *A full-grown larva*
5. *A pupa*
6. *A moth*

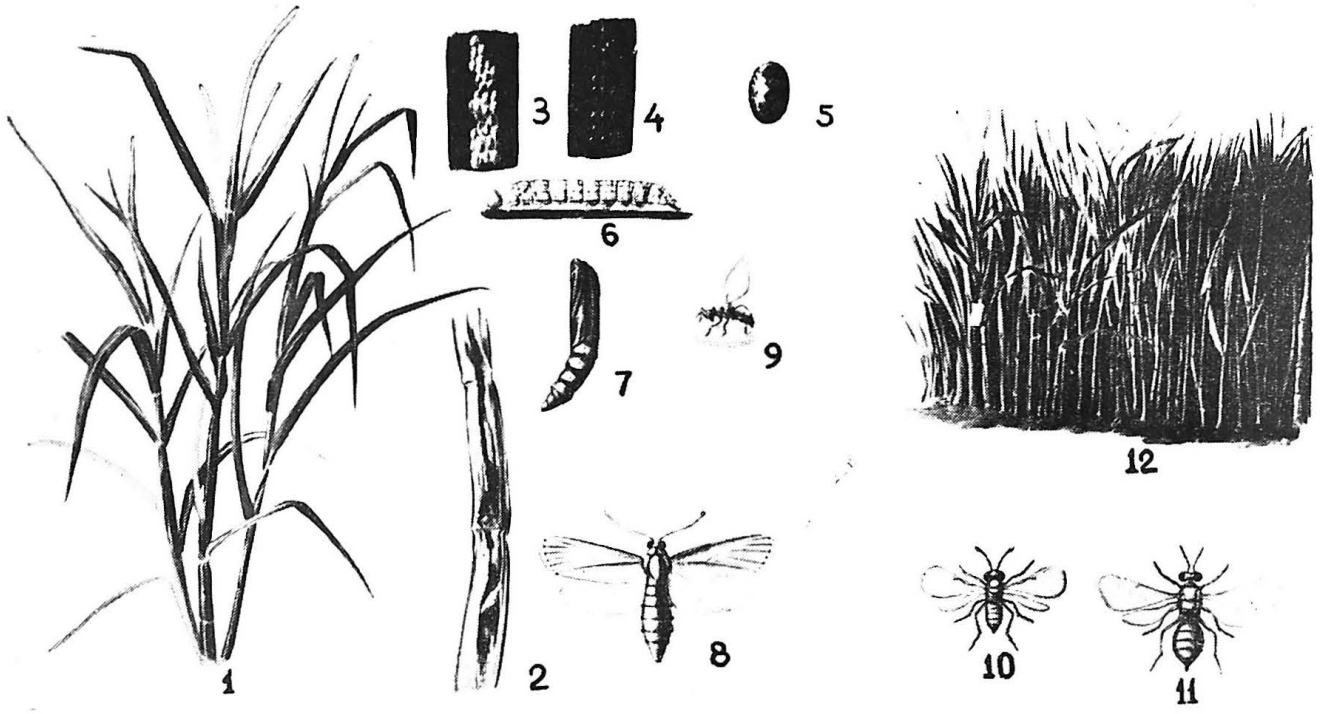
Sugarcane pests

The major pests of sugarcane are the caterpiller borers and the sugarcane leaf hopper *Pyrilla* that appear in an epidemic form in certain years. The major caterpillar borers are the top borer, *Scirpophga nivella* Fab., the stem borers, *Chilotraea infuscatellus* (Snellen), *Chilo tumidicostalis* (Hmpsn), *Proceros venosatus* (Wlk), and *Chilotraea auricilia* (Dudguon) and the root borers, *Emmalocera depressella* Swinh. The Indian Council of Agricultural Research has been financing a scheme for studying the biology and control of these pests on an all-India basis till 1944, when the work was taken over by the Indian Central Sugarcane

Committee. A co-ordinated programme of research work to control borers in the various sugarcane tracts in the country was planned from the Centre and the results of some items of research were recommended for general adoption in the different provinces and States. The biological control of sugarcane borers by the use of parasites was given special attention. A co-ordinated programme for the biological control of sugarcane stem borers by the liberation of colonisation and by their egg parasite, *Trichogramma evanescens minutum* Riley, was also planned from the Centre for the various sugarcane growing tracts of India and the trend of the results obtained from four centres, namely, Madras, Bombay, Bihar and Orissa has been encouraging. Besides, the biology of a number of promising parasites of potential importance has been studied in detail. In Punjab the biology and control of the top borer of sugarcane, *Scirpophaga nivella* Fab. which is one of the major pests of cane in Punjab, was studied in detail.

Pests of fruit trees

Three notorious insect pests of fruit trees, namely, the San José scale, *Quadraspidiotus perniciosus* Comst.,



Control of sugarcane stem-borer (Argyria sticticraspis) by means of the beneficial parasite Trichogramma evanescens minutum Riley.

1. *An affected plant showing the dead heart and the exit holes*
2. *A cane split open showing the full-fed caterpiller*
3. *An egg mass of the stem-borer*
4. *An egg mass parasitised*
5. *A parasitised egg of the stem-borer enlarged to show the exit hole of the parasite*
6. *A full-fed larva*
7. *A pupa*
8. *Adult moth*
9. *A female parasite in the act of oviposition*
10. *A male parasite*
11. *A female parasite*
12. *A view of the sugarcane field showing the parasite cards hung up*

the Cottony Cushion scale, *Icerya purchasi* Mask. and the Codling moth, *Carpocapsa pomonella* L, gained entry into our country in the past through inadequate quarantine regulations. The Council sanctioned a seheme for a survey of these serious pests with special reference to their incidence and distribution in the Indian Union. The Codling moth is not present now in our country as a result of partition. The Cottony Cushion scale is kept under check by the breeding and liberations of the lady bird beetle, *Rodolia cardinalis* Muls. A scheme was recently sanctioned by the Council for the importation and liberation of an exotic parasite from the U.S.A. for the control of the San José scale.

Leaf-curl of tobacco

In India, as in some other countries, tobacco suffers from a virus disease known as "Leaf-curl" which causes reduction in size and curling of the leaves. As a result of investigations it was discovered that the insect vector responsible for the leaf-curl in tobacco was the white-fly, *Bemisia tabaci* (Gen). Spraying with fish oil resin soap controlled the white-fly to some extent.

Insect pests of jowar

Studies on the incidence and biology of important insect pests of *jowar* were taken up at the Indian Agricultural Research Institute. It has been determined that the moisture contents of the grain have a great influence on the incidence and development of the pests. Disinfection of *jowar* by sun heat was tried and it was effective in heaps up to one inch on *pucca* floors and half inch in the case of *kucha* ones.

Other important research schemes

In recent years the insecticidal properties of a number of indigenous plants are under investigation in different States in order to find out cheap and effective insecticides. The experiments carried out so far have given valuable information of practical importance for the control of number of insect pests.

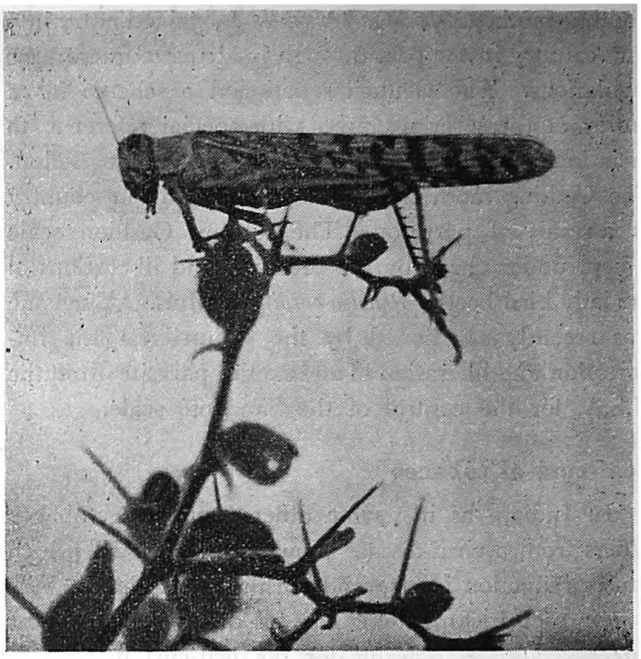
For training adequate personnel in systematic entomology, Schools of Reasearch in Entomology have been started at various centres. Mention may also be made of the scheme in Uttar Pradesh for the study of Wooly aphis, *Eriosoma lanigerum* Hausm, and apple root borer, *Lophosternus hugelii* Redterb and other fruit pests like scale insects and defoliating beetles. In Mysore a novel scheme was sanctioned to explore the insecticidal property of plant fish poisons and other forest products. In Madhya Pradesh a research scheme for the control of the Cecidomyid fly *Pachydiplosis oryzae* Mani, a very serious pest of rice, was sanctioned. In this scheme the effect of light trap and alternate hosts were studied in detail. In Bengal schemes for the investigations on the ecology and control of the stem borer of rice, *Schoenobius incertellus* Wlk., and the rice hispa, *Hispa armigera*, were sanctioned. In Bihar investigations were carried out for the control of the potato tuber moth, *Gnorimoschema operculella* Zell. Research work on insect pests of stored cereal grains was carried out in Punjab. In Madras, a scheme was sanctioned for the study and control of cardamom thrips, *Teniothrips cardamomi* Ayyar, a serious pest of cardamom in South India. There were also schemes in Madhya Pradesh and Coorg for the study and control of insect pests of citrus.

The Council has started two Bee-keeping Research Stations, one in the north in Punjab and the other in the south at Coimbatore with the special purpose of augmenting the honey yielding qualities of the Indian honey bee, *Apis indica*, by the breeding of pedigree queens.

Desert locust

by

K. B. Lal



Desert locust (adult)

OF the three species of locusts that occur in the Indian region, the desert locust, *Schistocerca gregaria* Forsk., is by far the most destructive. The desert locust outbreak of 1926-31, during which crops of the value of 10 crores of rupees were estimated to have been lost, focussed attention on the need for planned investigations on the pest. The very first problem to which the Indian Council of Agricultural Research addressed itself, on its establishment in 1929, was that of the desert locust. As a result, a comprehensive locust research scheme was started under the auspices of the Council in December 1930, which continued till March 31, 1939. The headquarters of the scheme was at Lyallpur, where the life history and bionomics of the desert locust were studied. A survey of locust was also undertaken in Baluchistan, Sind and Rajputana.

Problems involved

When the researches started, not much was known about the life history, habits and behaviour of the desert locust beyond the fact that its swarms came periodically from somewhere in the west and that Baluchistan was a possible source of at least some of those swarms. However, the famous " phase theory " had been propounded, according to which the locusts were known to live and breed endemically as solitary individuals (solitary phase) in their permanent breeding grounds during their non-active cycles and assume gregarious characters and habits (gregarious phase) during their active cycles, leading to the formation of swarms and mass migrations. Some of the first questions that arose, therefore, were: where exactly did the solitary locusts endemically live, what factors contributed to their gregarisation and mass breeding, where did the swarms originate from, what factors led to their formation and mass migrations, what was the potential capacity of the desert locust to multiply ? These and other questions demanded answers if the locust outbreaks were to be predicted and controlled.

At Lyallpur, experiments were set up in the laboratory under controlled conditions and in field cages and the observations were correlated with those made in the field in Punjab, Baluchistan and other areas. Almost the first important findings were that, given the most favourable conditions of temperature, humidity and soil, the desert locust could breed throughout the year and produce a maximum of eight successive generations. No cessation of development need occur in any of its stages, the duration of which as well as of various life processes depended upon environmental conditions " of which temperature is by far the most important ". It was found that the adult locusts lived for about a month at temperatures above 36°C. but at temperatures below 30°C. the longevity was prolonged to two to three months or even more. The period during which sexual maturity was acquired varied from 14.2 days at 40°C. to 32 days at 27°C. and was much prolonged if a temperature below 20°C. prevailed for a long time. Likewise, the period taken by the

A band of locust hoppers

eggs to hatch varied from 85 days at 18.5°C. to a minimum of 9 days at a temperature above 40°C. At 27°C., the hoppers (locust young ones) required 62-63 days to complete their development and become adults, but only 20 days at temperatures between 36°C. and 40°C. No development, either of the eggs or of the hoppers, occurred at temperatures below 17°–18°C. or over 45°C., which respectively represented the lower and upper vital limits of temperature for the desert locust.

Factors affecting breeding

It was observed that in nature, the breeding of the desert locust appeared to be influenced predominently by the presence of an optimum amount of soil moisutre, which in turn depended on rainfall. Generally, there was only one generation in a particular area but, as the locusts migrated from one area to another, receiving rainfall at different times of the year, two generations in a year were commonly observed and three could be expected. This happened in the pre-partition Punjab and in Baluchistan where breeding occurred during February-April and July-September as a result of winter and monsoon rainfalls. However, in years of heavy or unusual rainfall, breeding was observed to occur in places where it was normally not expected, since " locusts tend to leave areas of drought and migrate elsewhere ".

Practically the entire period of the research scheme coincided with the non-active cycle of the desert locust, but perhaps this very fact enabled valuable information to be obtained about the distribution of the solitary locusts, the formation of incipient swarms and the initiation of active cycles. Investigations proved as fruitful in the field as in the laboratory. In 1930 it was not definitely known whether the periodical locust plagues in India were the results merely of breeding in Baluchistan or of a chain of connected breedings in Baluchistan, Iran and Arabia and possibly other areas. Extensive, preliminary surveys were, therefore, conducted in the desert and semi-desert areas of North-West India during 1931-33, which indicated the general distribution of the solitary locusts. The information had reference only to the conditions prevailing during the particular periods of the survey and was not sufficient to determine permanent breeding grounds or outbreak centres. From June 1933, therefore, the extensive surveys were replaced by " intensive regional surveys'" which provided definite indications about the locust situation in different areas in different seasons. It was soon realised that even these intensive surveys could not afford a continuous picture of locust incidences, movements and breeding at particular places throughout the year. In 1934, therefore, " intensive local surveys" were instituted to supplement the information obtained from the " intensive regional surveys'". Both

the surveys continued till the end of the scheme when the Government of India established a permanent Locust Warning Organisation for similar purposes.

Locust and weather changes

The results of the surveys showed a "striking correlation" between the life events of the solitary locusts and seasonal weather changes. Fluctuations in the locust populations were clearly attributable to deviations in the weather conditions. The extent and intensity of spring breeding on the western Mekran coast in Baluchistan were found to be directly dependent on the amount of the winter rainfall received. The locusts moved from the coastal areas to the interior where concentrated breeding occurred if there was good rainfall in spring giving rise to incipient swarms. Thus were the outbreak centres formed such as the one which developed in the Kilwa area in March-April, 1936. With the general rise of the maximum atmospheric temperatures to over 100°F. and corresponding fall in humidity, the locusts migrated to the western Sind and thence to the south-west Punjab and Rajputana. If, however, north-west winds prevailed, the locusts headed from the interior towards the coastal areas but even from there they ultimately "gravitated" to the desert areas *via* Lasbela and Sind. The immigrant locusts bred in the Sind-Rajputana area in the wake of the summer rainfall. Summer breeding also occurred in Lasbela, Kachhi and Mekran areas of Baluchistan whenever the monsoon extended up to these places. The summer breeding continued in waves till autumn and, given good and well distributed rainfall, a second summer generation could be produced. High temperatures and drought, following the monsoon season, forced the locusts to leave their summer breeding areas and the greater number of them flew towards Sind and Baluchistan with north-easterly and easterly winds during September-October. However, adults developing in late October or early November did not find conditions very uncongineal and had not much urge to leave, though a certain proportion of them did migrate towards the west during short spells of warm weather. During winter, locust activity was extremely low and the over-wintered individuals bred in winter rain areas. Thus was the cycle of events completed.

Previous conception

One great value of the investigations lay in correcting a previous conception of the origin of locust outbreaks, according to which, solitary locusts lived and bred in their permanent breeding grounds but during one or two successive years of favourable conditions, specially a heavy and well-distributed rainfall, would multiply intensively, build up large populations and form swarms of gregarious locusts which would fly to distant areas, thus giving rise to an active locust cycle. The investigations under review, however, showed that the populations of the solitary locusts were seldom static but fluctuated markedly in density, not only on account of local breeding but also because of immi-

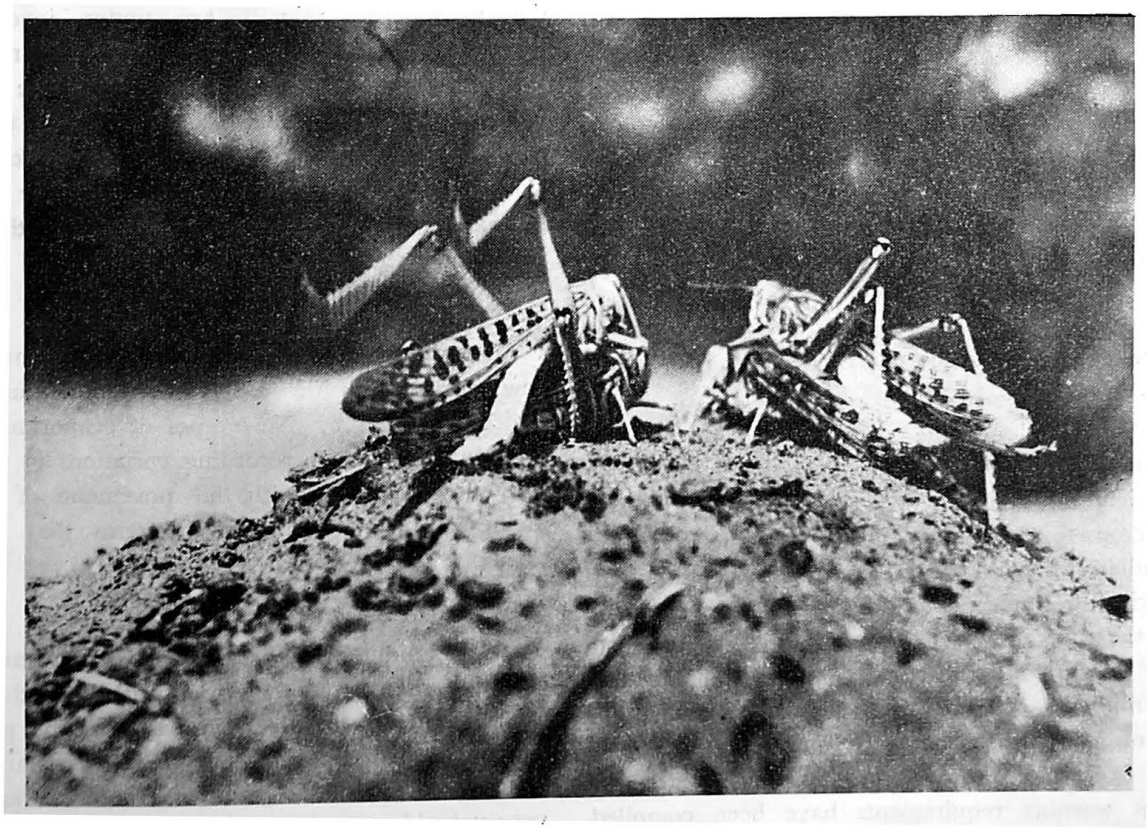
Locust hoppers congregated on a bush

gration or emigration of individuals. Secondly, solitary locusts could migrate to long distances so as to reach winter or summer rainfall areas and, thirdly, the change over from solitary to gregarious locusts occurred in "certain ecologically peculiar locations—the outbreak centres" often far from the permanent breeding grounds.

The investigations also revealed that the same sequence of activities occurred in the life cycles of the solitary and the gregarious locusts. Both over-wintered and bred in the winter rain areas. Both migrated from the coastal areas to the interior during spring and bred there. Both migrated eastwards during summer and bred in the desert regions during the monsoon rains and both migrated again towards the west during the autumn to over-winter. Both were similarly affected by meteorological and ecological conditions. Indeed both were the same insect species. The differences lay in the greater intensity of activities and greater extensiveness of flights by the gregarious than by the solitary locusts.

Biology and ecology

The investigations covered various other aspects of locust biology and ecology and also of technique. For example, experiments showed that the colouration of the solitary (green) and gregarious (blackish) hoppers could be changed at will by rearing them singly or crowded in atmospheres containing more or less concentrations of carbondioxide and by subjecting them to rest or exertions. The food preferences of the desert locust were studied and about 200 wild and cultivated plants were classified as readily acceptable, reluctantly acceptable or not acceptable at all. It was also found that certain wild and cultivated food plants, *Sorghum* among the latter, hastened not only sexual maturity but also the development of hoppers. An explanation was found for locusts eating non-edible substances like wool in that they did so only to obtain moisture. Biometerical studies of body parts, including eye stripes, furnished clues for determining the stage of development of a locust population with regard to its tendency towards gregarisation or solitarisation. A method and a formula for estimating the population density of the locusts in the field have been evolved.



Locusts pairing

Agricultural meteorology

by
L. A. Ramdas

THE Indian Council of Agricultral Research immediately after its formation, sanctioned the creation of a Division of Agricultural Meteorology at the Meteorological Office, Poona. The Government of India took over Agricultural Meteorology Division from the Council, temporarily in 1940 and on a permanent basis in 1943.

The Council sanctioned the co-ordinated crop-weather scheme in 1945. This scheme, taken over by the Government of India in 1950, envisages the recording of systematic crop and weather observations at a net work of selected experimental farms in India, so as to ensure that in future all the relevant biological and meteorological data might be recorded in our country according to a standard plan. Such data collected for a sufficiently long period of years can provide a proper basis for working out reliable crop-weather relationships. The Council sanctioned this scheme in respect of three major food crops, *viz.*, paddy, wheat and *jowar*.

The lead given by the Council was immediately followed by the Indian Central Sugarcane Committee (1946) and the Indian Central Cotton Committee (1947), both of which sanctioned schemes with regard to sugarcane and cotton crops respectively on similar terms.

The weather service for the farmer

In the weather service for agriculture inaugurated in 1945, the role of the Agricultural Meteorology Division is a liaison one, *viz.*, to bring the problems of the agriculturist and the actual warning requirements of his crops to the notice of the weather forcasters of the Indian Meteorological Department, and to tell the agricultural officers and the farmers in the country, about the ways in which meteorology can come to the aid of agriculture. Three volumes of district-wise and crop-wise crop-weather calendars showing the dates of commencement and duration of various phases of crop growth and their normal weather as well as warning requirements have been compiled. The farmers' weather bulletins are prepared by the five Regional Forecasting Centres of the Indian Meteorological Department and broadcast by the All-India Radio stations in the local Indian languages.

The Central Agricultural Meteorological Observatory, Poona

The Observatory was founded in 1933. It has grown rapidly and is equipped with a full complement of routine, special and self-recording meteorological instruments as well as many new instruments specially devised. This institution has been extremely valuable as a centre for conducting experimental researches in agricultural meteorology out in the field and amongst crops; it also serves as a training centre for agricultural research workers and assistants deputed to Poona by the different States.

Studies on the micro-climates of crops carried out at the observatory show that the temperature inside a crop is much lower and the humidity percentage much higher than in the open. When a crop develops a canopy (*e.g.* sugarcane) these deviations are most pronounced. It is the micro-climate that controls the plant growth as well as the conditions in which it may be infested with pests or diseases.

The factors controlling the disposal of solar radiation as well as rainfall are under investigation. Studies on testing plant varieties for drought resistance, soil permeability in relation to its structure and salt content, the physics of sub-soil irrigation, radiation, etc. are also in progress at the observatory. The Council has very recently sanctioned a scheme for evolving experimental techniques for studying the water requirements of crops.

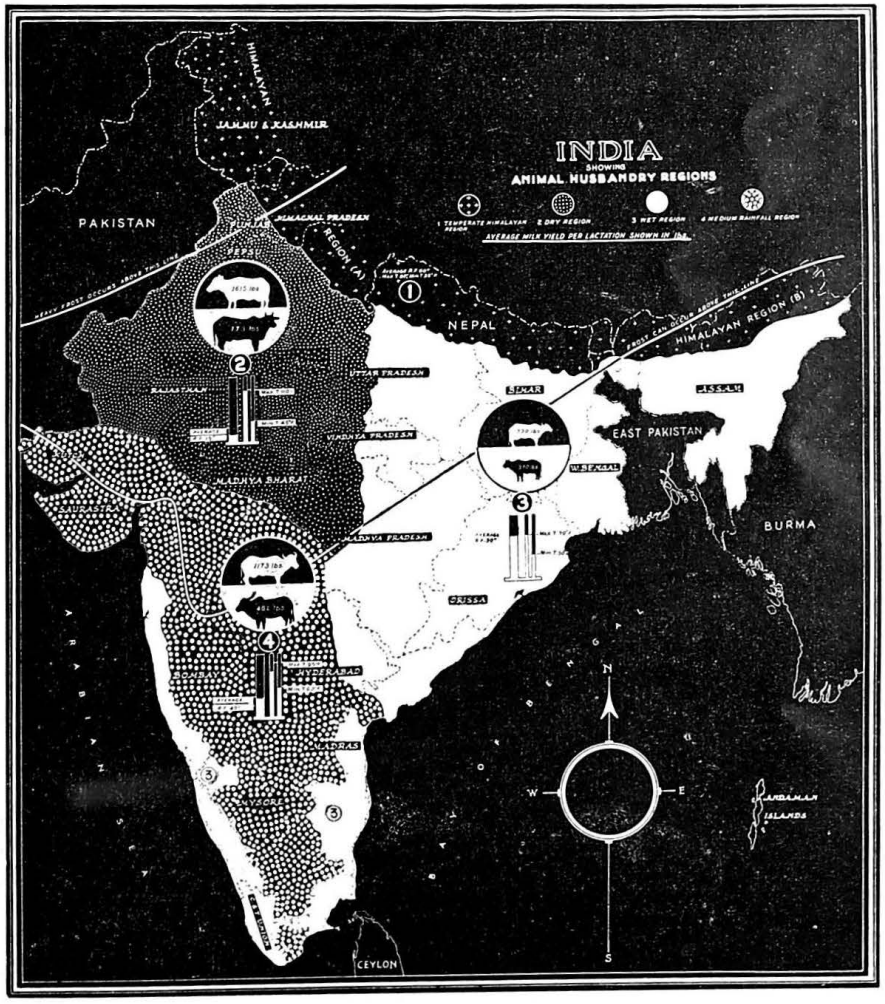
New instruments

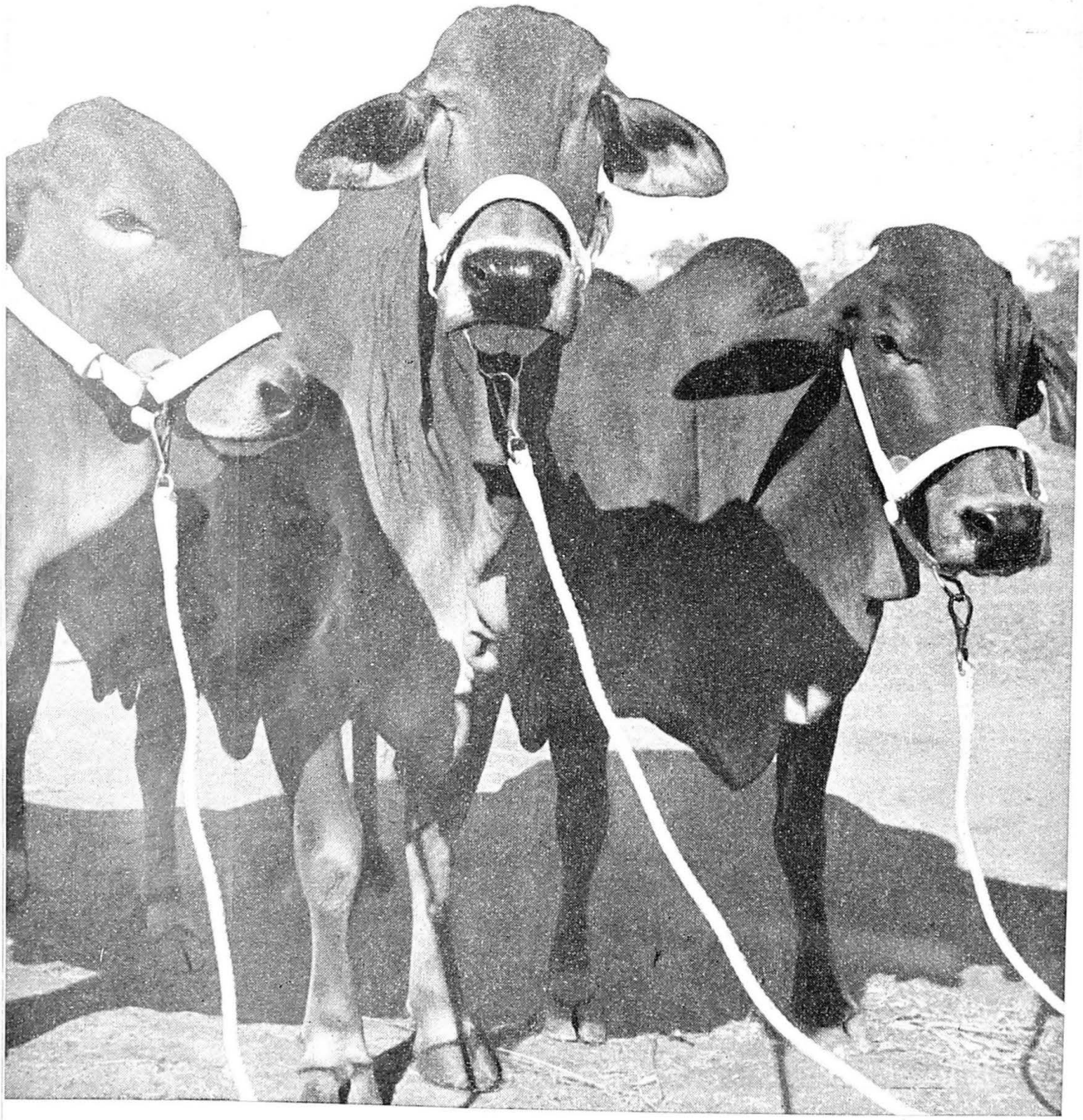
The workers at Poona have devised a number of new instruments which are of use in agricultural meteorological research. New types of evaporimeters, an electronic bridge for recording variations in electrical resistance associated with the movements of moisture in the soil, etc. are some of the items that may be mentioned.

All-India crop outlooks

A technique has been developed whereby an objective assessment of the crop outlook at the end of each month on an all-India basis can be prepared. These tentative outlooks are being sent regularly to the Ministry of Food and Agriculture who have found them very valuable.

ANIMAL HUSBANDRY



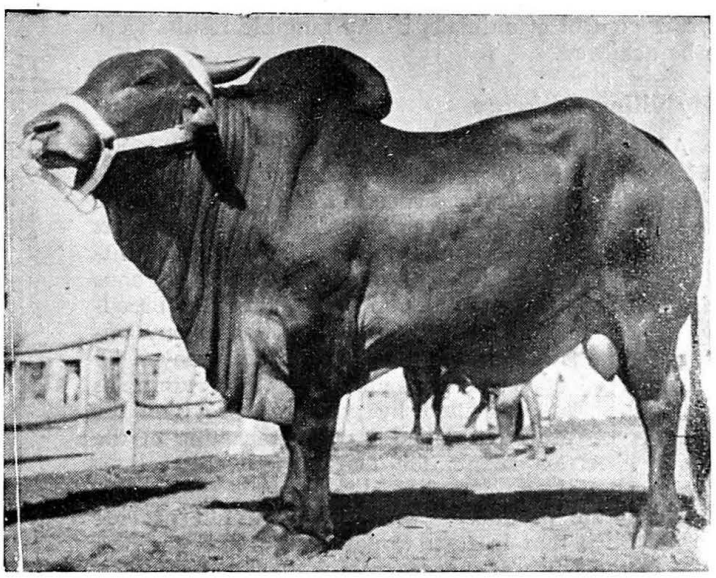


A record milk yielding Sahiwal cow with daughter and grand-daughter

Cattle Breeding

by

P. N. Nanda



Red Sindhi bull

DEVELOPMENT in animal husbandry has made considerable strides since the inception of the Indian Council of Agricultural Research in 1929. Cattle undoubtedly form the most important part of the livestock industry of India. Before attempting to assess the progress made in cattle breeding under the aegis of the Indian Council of Agricultural Research, certain basic facts as indicated below have to be borne in mind.

The development of cattle is time consuming, and to obtain lasting improvement, systematic breeding plans must be diligently continued over 4-5 generations, *i.e.* 15-20 years.

The present low level production of Indian cattle is not due to any intrinsic inability on their part to produce, but because of lack of necessary environmental conditions for their successful exploitation. Scientific breeding, adequate feeding and efficient disease control must all be simultaneously made available, if any progress is to be made. Unfortunately, under the conditions obtaining at present, the resources of this country cannot maintain, on an adequate plane of nutrition, more than half the existing cattle population. Breeding facilities are inadequate to the extent that there is one pedigree bull where 250 are required. In spite of the measures directed towards the elimination and control of cattle diseases, a large number of animals still die, or are rendered unfit for long periods.

It is almost impossible in many of the animal husbandry research schemes to actually measure improvement or the extent of benefits which accrue as a result of these researches. Even where it is possible, there is no agency in existence in the country at present, which could be entrusted with the task of conducting periodic systematic assessment of the progress made.

It would thus be seen from what has been stated that the development of India's 200 million cattle is a colossal task and any steps initiated to achieve the objective must, therefore, approach the problem from several angles in a co-ordinated manner.

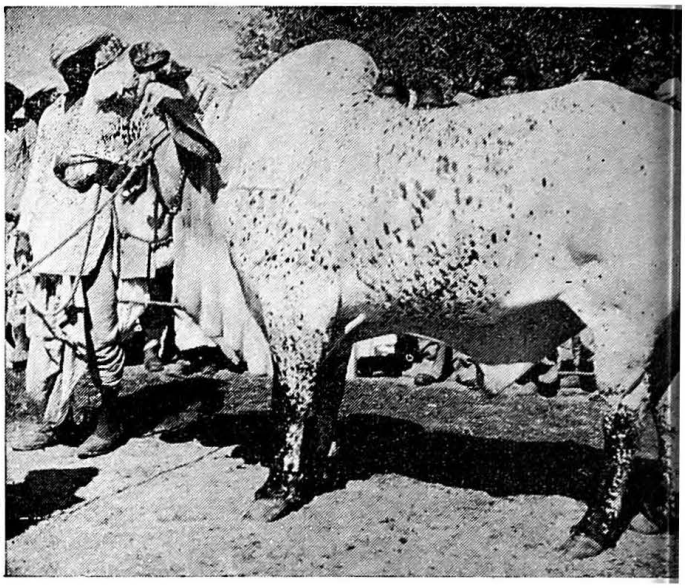
Pilot projects

The Indian Council of Agricultural Research has been, since its inception, interesting itself in evolving suitable techniques and plans which would bring about lasting improvement in the country's cattle wealth. Certain pilot projects were accordingly introduced by the Council in different parts of the country with a view to evolve measures which would induce the average breeder in the country-side to produce and maintain better cattle. These pilot schemes yielded valuable information and also brought to light drawbacks and defects in the practices which had been hitherto followed. For instance, it was realised that the time-honoured practice of distributing farm-bred bulls to serve in very large areas, without regard to continuity of such supplies and without clearing the area of unapproved bulls, was of little or no value. It was also felt that a proper approach to the villager to enlist his full co-operation, which is the *sine qua non* of success in the huge task of developing the cattle of India, was essential. It was further realised that all development work should be done in the villages by the villagers in conditions in which they live and work. Another important observation made from the pilot schemes was that mere production and use of better bulls was no solution, but that simultaneous steps must also be taken to improve the feeding, management and

disease control of animals, if any tangible results were to be achieved.

Key village scheme

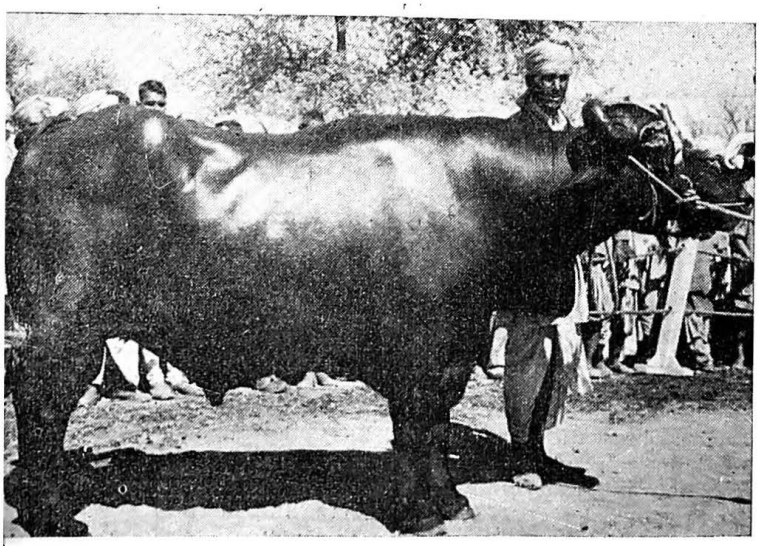
After a careful study, the Council evolved what is known as the "Key Village Scheme". Under this scheme, efforts are concentrated in selected areas, where the superior pedigree bulls produced in the Government farms, are sought to be multiplied. In these concentrated areas comprizing of one or more contiguous villages but with a population of 2000 cows of breeding age, pure-bred bulls are to be used and any unapproved and undesirable males are to be removed by castration or otherwise. The breeding programme is also to be supplemented by adequate provision for feeding, disease control and proper marketing of the produce. Arrangements for marketing would eliminate the middleman, and would ensure a satisfactory return to the producer. This profit would provide the incentive that in turn would ensure the co-operation of the villagers,-an essential-factor for the-success of the programme. The modern technique of artificial insemination is also to be used as far as possible to make up for the shortage of high class bulls in order to accelarate the pace of progress. Bulls of proven value would also be put to the widest possible use. The scheme for the present, envisages the establishment of 150 artificial insemination stations and 600 key villages covering approximately a population of 12 lakh of cows fit for breeding. The key village plan has since been accepted by the Planning Commission and is now in progress. On September 1, 1954, 112 artificial insemination stations and over 340 key village centres had been established. By working the plan strictly in accordance with the approved technical programme, the country will not only be able to produce in course of time about 25 per cent of its annual requirements of breeding bulls, but would also bring about a substantial increase in the average milk yield. Briefly stated, the implementation of the key village scheme is one of the most striking achievements of the Council in recent years.



Deoni bull

It would be relevant in this connection to indicate the observations made by some members at the last meeting of the Governing Body of the Council. It was stated that it was now extremely difficult to buy a 15-seer cow or a 20- seer buffalo in the Hariana tract, whereas such animals were easily available in the area a few years ago. It has been vaguely hinted in some quarters that instead of improvement there has been deterioration in the quality of cattle in this country. Although no specific or systematic assessment has ever been carried out to measure the productive capacity of our cattle, yet it is true that the high yielding animals in the breeding tracts are not to be found in as much abundance as they were some years ago. This is, however, due to the fact that in the pre-partition days, such animals were available from amongst the several well-known milch breeds now in Pakistan. When the supply of these animals was cut off, the breeding tracts in India were called upon to meet all the demand for such cattle in large cities and this demand was so heavy that the tracts have not been able to cope with it. There has thus been some deterioration in quality in consequence. The problem would, therefore, seem to call for suitable measures for controlled movement from the breeding tracts and should not obviously be taken to indicate that the deterioration is due to inadequacy of breeding programmes or any inherent flaw in our researches and their application to the field.

Murrah buffalo



Realizing the long-term nature of all cattle improvement plans, the Council in consultation with the State Directors of Animal Husbandry has laid down a breeding policy for the entire country. This has since been accepted by the State Governments and development plans have been taken in hand accordingly.

Dual purpose cattle

Considerable progress has been made in the evolution of dual purpose animals, *i.e.*, animals which should produce good work bullocks and also yield a fair amount of milk. Work done under the aegis of the Council has shown that there are considerable possibilities of developing the milk yield of the purely draft breeds without detriment to their work qualities.

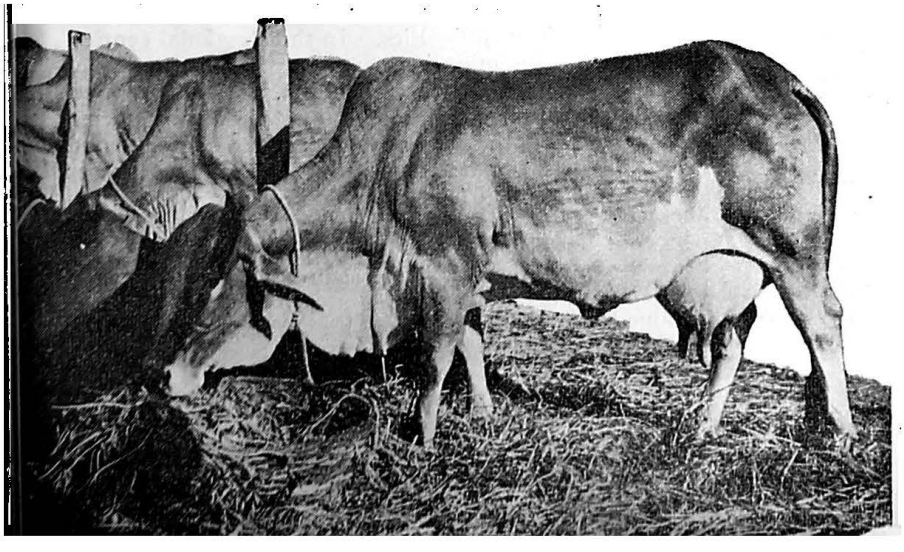
Central Herd Books

Registration of pedigrees and recording of production has been accepted all the world over as the only sound basis of cattle development. The Council realized this almost from its very inception and took necessary steps to establish Central Herd Books for all the well-established breeds in the country, each of which has been carefully defined as regards its breed characteristics. These breed definitions have been published and form standard works of reference for the guidance of breeders. The introduction of pedigree registration is an important landmark in the history of cattle development in India.

A pilot scheme for collection and marketing of village milk, combined with insurance of milch animals, has shown considerable promise of adoption on a wider scale. At a small premium deducted from the sale of milk, the animals are insured against loss due to accident and disease and this helps the farmers to breed and maintain better cattle.

There are several other problems, work on which is in progress. For instance, a comparative study has been undertaken of the performance of local types of cattle when bred and fed under suitable conditions and that of graded animals obtained with the help of well-known breeds. The result would be judged from the point of view of adaptability and economic production and should thus be of vital interest to several areas which at present depend entirely on animals brought from other parts of the country. Similarly, after a careful study, a number of centres for cross-breeding with foreign bulls have been established in selected hilly and heavy rainfall areas. Most of the centres are intended to employ the modern technique of artificial insemination, using semen supplied from the Central Artificial Insemination Station which has been established at Bangalore.

As has been mentioned earlier, it is a matter of considerable gratification that after years of experimentation, a comprehensive but practical plan for the development of cattle has been evolved which promises to influence the entire cattle industry of the country. In addition from the results achieved or progress attained in several other schemes sponsored by the Council, it is apparent how vital a role the Council is playing in the development of an industry which is of paramount importance to the nation.

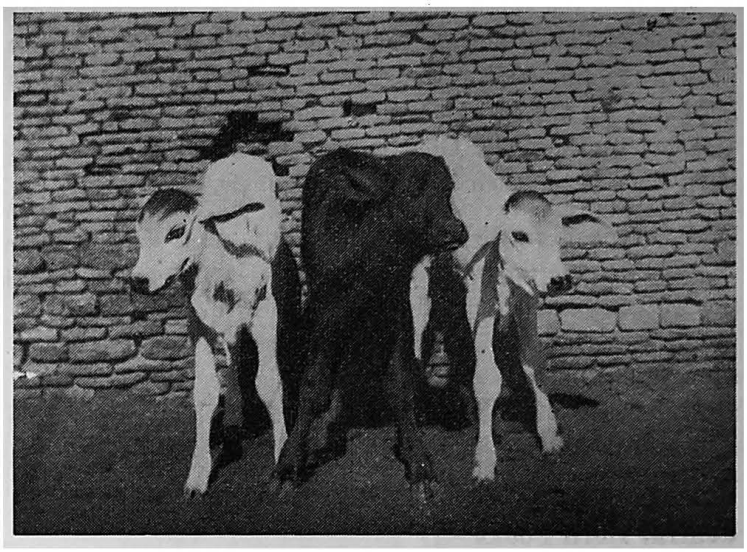


Sahiwal cows

Animal genetics

by

P. Bhattacharya



A batch of test-tube calves at the Government Livestock Farm, Hissar

IT has been estimated that one-fifth of the total income of the people in this country is derived directly or indirectly from livestock products in the form of work, milk, wool, meat, egg and manure. In spite of this, a close scrutiny will show that this is only a fraction of the total benefits that could have accrued to us. This is due to the fact that through years of neglect and indiscriminate breeding, our farm animals have become nondescript and are very poor in performance record.

The foundation of scientific breeding work in this country was laid by the advent of the Indian Council of Agricultural Research. A practical step towards improved cattle breeding was the opening of Central Herd Book registration system for the important milch breeds by the Council. The introduction of artificial insemination system in India owes its origin to a scheme first initiated by the Council in this country.

Studies on Mendelian characters

Investigations conducted at Allahabad indicated that the bilaterally symmetrical white patch, found on the flanks of certain Sahiwal cattle, was due to a dominant gene. Similar studies at Anand, revealed a hereditary basis for the red coat colour in Kankrej calves. Studies made at Izatnagar on the inheritance of syndactylism of one or both fore feet in Hariana cattle showed that the defect was due to an autosomal recessive gene.

In poultry, studies at Izatnagar have revealed that the lateral curling in the toes of both *desi* and Rhode Island Red birds to be autosomal recessive in nature. Such birds were also found to be unproductive.

Cytological studies carried out at Izatnagar showed that the Indian water buffalo (*Bubalus bubalis*) has 48 chromosomes in the diploid stage.

Artificial insemination

To bring about rapid improvement in heriditary qualities, the greatest possible use of available superior sires should be made. This is only possible by extensive use of artificial insemination. The work on artificial insemination was started in 1942 at Izatnagar and studies were made to determine the suitability of various techniques developed abroad on collection of semen, its preservation and insemination. It was demonstrated that the techniques in their broad aspects could be successfully used under Indian conditions. With a view to finding out how artificial insemination would work under the various conditions peculiar to this country, the Izatnagar Institute opened four regional centres at Calcutta, Montgomery (now in Pakistan), Patna and Bangalore. This scheme had amply demonstrated the practicability of artificial insemination inspite of various difficulties. In these regional centres, about 23,000 inseminations were carried out and over 4,000 animals treated for infertility. At these centres, the highest number of inseminations performed during a year was 4474, the largest number of cows inseminated from a single ejaculate was 24, and the highest number of cows inseminated from a single bull was 1809. The average fertility was about 58 per cent for cows and 63 per cent for buffaloes. Calves were produced in Malabar and Bengal from semen transported from Bangalore and Izatnagar, and cross-bred Jersey calf was obtained at Bangalore from air lifted semen from England.

Artificial insemination also features prominently in the master plan of cattle regeneration, the " Key Village Scheme ", which envisages opening of 150 artificial insemination centres in 600 key villages in the first phase of its work. Calves have been obtained with semen preserved for 10 days and a cheap portable semen container has been designed.

Studies on semen of farm animals

Systematic studies were taken up at Izatnagar on the normal semen characteristics of Sahiwal, Hariana, Kumauni Hill cattle, Murrah buffaloes, goats, sheep, White Laghorns and *desi* birds. The morphological changes leading to maturity of spermatozoa in buffaloes, sheep and goats were also studied. Biochemical studies on semen in different species of farm animals, including poultry, have revealed a lower percentage of fructose in the reducing substances in buffalo semen in comparison to the other species. This knowledge may help in evolving a better dilutor for buffalo semen. Moderate exercise for a short period did not seem to materially affect semen quality. No difference in semen production was observed between bulls maintained on proteins from plant and animal origin.

Reproductive physiology

The secondary overall sex ratio of normal births in Indian cattle was found to be 103.93 males for 100 females. Some breed difference in this character was noticed and it was also found that the highest number of abortions (25.46 per cent) occurred in the second gestation after which there was a gradual fall. The overall average gestation period was found to be 282-288 days, Sindhi having the lowest and Hallikar the longest period.

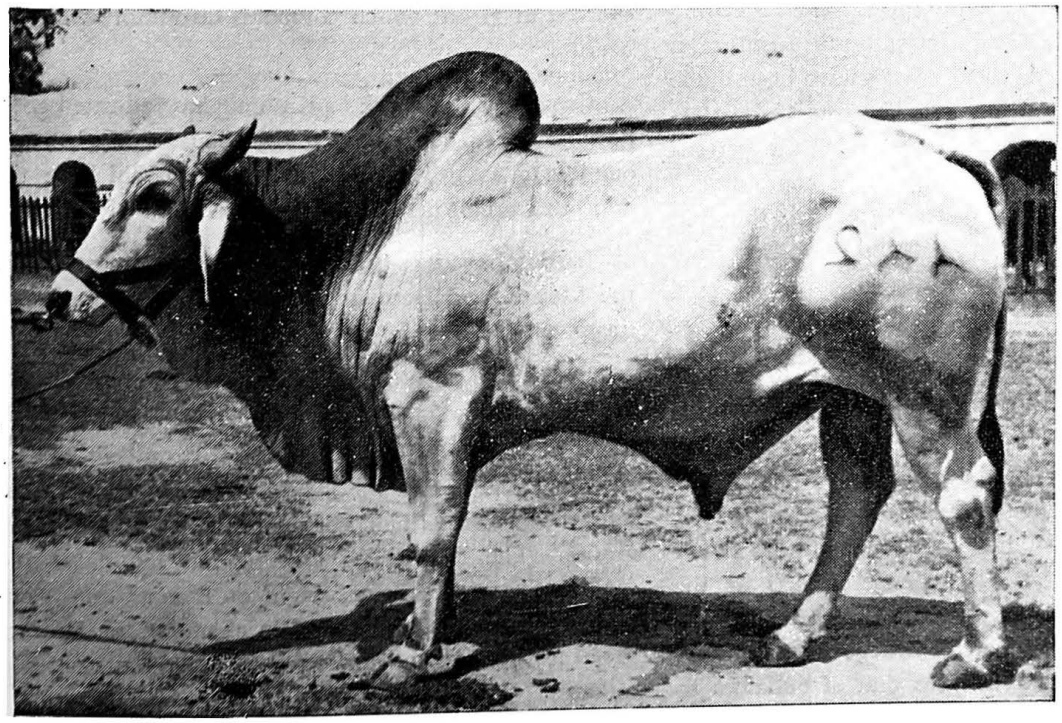
Studies on infertility

In a survey carried out on about 20,000 animals at various cattle breeding and dairy farms and at a number of key village centres, 22.23 per cent heifers, 11.35 per cent cows, 10.28 per cent buffalo heifers, 6.26 per cent buffalo cows, 11.15 per cent bulls and 3.65 per cent buffalo bulls were found to be infertile.

At Izatnagar successful attempts were made to shorten the inter-calving period of cows and buffaloes by hormonal treatment with P.M.S. gonadotrophin by inducing oestrus and ovulation within 2-4 days after treatment. Most of the treated animals conceived at the induced heat. P.M.S. was prepared and purified at Izatnagar. Investigations have also been initiated to find out painless, cheap and effective methods for making unproductive cows sterile.

Climate and livestock breeding

Studies carried out at Izatnagar showed that the various attributes of semen of bulls, rams, bucks and buffalo bulls are greatly influenced by atmospheric temperature and humidity. High air temperature associated with high humidity had an adverse effect on their semen quality. It was further observed that the trend of seasonal variation in the semen attributes was



A semen donar

similar to the trend of haematological constituents. Two hormonal products, P.M.S. and Thyroprotein, have been tried in allaying summer sub-fertility in Indian farm animals. Administration of P.M.S. has been found to help in improving the poor semen quality in rams during hot, humid climate.

Cattle breeding

By continued selective breeding, the yield of individual cows rose to 10,000 to 13,000 lb. of milk in a lactation of 305 days in the Sahiwal herd at the Indian Agricultural Research Institute. Similarly Red Sindhi herds at Indian Dairy Research Institute, Allahabad Agricultural Institute and Hosur Livestock Farm recorded milk yields of 10,000 lb. in 305 days. Tharparkar herds of Patna and Karnal went up to 10,000 lb. and the Gir herd of Indian Dairy Research Institute exceeded 6,000 lb. The Kankrej herd of Anand, and the Kangayam herd of Pallayakotai have likewise exceeded 8,000 lb. and 4,000 lb. of milk respectively, though they were previously considered purely draft breeds and poor in milking capacity. Work with the Gaolao breed at Wardha has shown it to be capable of better milking capacity than it was hitherto accredited with. The Hariana herd transferred from Karnal to Izatnagar, also improved considerably and individual lactations of 6,000 to 7,000 lb. of milk have been recorded.

Cross-breeding

Except for commercial exploitation and for purposes of research, cross-breeding almost became a taboo. One experiment on Indo-European cross-breeding conducted at the Allahabad Agricultural Institute is worth mentioning. Reciprocal crosses have been made between Red Sindhi and Jersey. The trend of performance of the small numbers obtained for the various grades seems to indicate that a genotype combining a little less than 3/4th Jersey inheritance with the Red Sindhi may result in evolving a useful Indo-European dairy breed for Indian conditions.

Cow and buffalo

The average annual milk yield per buffalo is 1,100 lb. as against 413 lb. given by an Indian cow. Buffalo milk being 1½ times as rich in fat content as the cow's milk is more valuable for butter and *ghee* production. Buffaloes are also better utilizers of coarse fodder. Being more economical, buffaloes are naturally better looked after than cows. Experience gained at the Government farms has shown that by better feeding and management, the production of village cows may be increased by 50 per cent whereas that of buffaloes by only 15 per cent. It must, however, be mentioned that in view of the early maturity of the cow, and greater usefulness of its male calves as draft animals, this species has more overall utility. Murrah has found a place in the Herd Book system, the qualifying limit being a minimum of 3,000 lb. milk in 305 days.

Goat breeding

One of the earlier efforts in this direction was the goat breeding scheme at Etah. Selective breeding and grading was taken up in Punjab with the Beetal and Jamnapari breeds, in Uttar Pradesh with the Barbari and Jamnapari breeds, in Bihar with the Barbari breed, in Orissa with the Beetal and Black Bengal Breeds and in Travancore-Cochin State with the Malabar breed. Black Bengal is a prolific mutton breed with good scope for carcass development, while others are more valued for milk production.

Some pioneering work has been done in Punjab to develop mohair producing quality in the local and hill goats by cross-breeding them with the Angora bucks imported from South Africa. The third generation animals were the most successful mohair producers yielding 5 lb. a year.

Sheep breeding

By crossing the Bikaneri sheep with the imported Merino, it was found that a type having seven-eighths Morino inheritance was obtained and by inter-breeding these, a new breed called the Hissardale has been evolved at Hissar which compares favourably with the Merino.

Cross-breeding work in Kashmir has indicated good possibilities of developing a three-fourths Merino and one-fourth local Kashmir sheep, which will have the approved uniformity of fine quality wool.

In Bombay cross-breeding work is in progress with the Merino and Deccani sheep for a better wool type sheep.

Selective breeding in Madras, Bihar, Hissar and Poona has also yielded very good results. The black faced Bellary breed of Madras is progressively gaining in wool quality, and the local coloured sheep of Bihar have been losing their colour incidence in successive grades. The Bikaneri is forming out into light and medium types of Hissar, while at Bombay much improvement has been achieved in changing the Deccani sheep from black and hairy to white and wooly fleeced animals.

Animal diseases

by

S. Datta

ON a rough estimate, about 20 lakhs of cattle are affected every year by infectious diseases, out of which about two lakhs perish. The loss sustained due to epizootics in cattle alone is of the order of Rs. 20 crores annually. Besides this, a much larger number of animals suffer from various chronic diseases caused by protozoa and helminths.

Despite serious limitations, the veterinary scientists have been able to develop effective remedies against most of the serious animal diseases prevailing in this country, and have undertaken studies on problems pertaining to animal nutrition, breeding and technology. Fairly large quantities of over 25 different biological products, evolved as a result of continuous research, are now produced at Izatnagar and other centres.

When the Indian Council of Agricultural Research came into being in 1929, the State Veterinary Departments were under-staffed and lacked co-ordination, with the result that they remained engrossed with the task of routine disease control and administration. With few exceptions, the State Veterinary Departments had practically no facilities for research on animal diseases and for undertaking developmental programmes. The Imperial Institute of Veterinary Research was also poorly organized. The financial aid offered by the Council, however, made it possible for many States to initiate research on certain important aspects of animal husbandry. The schemes of veterinary disease investigation were the first research projects that thus came into existence in States. The work of these schemes has throughout been carried out in close collaboration between the field workers and the specialists of the Indian Veterinary Research Institute.

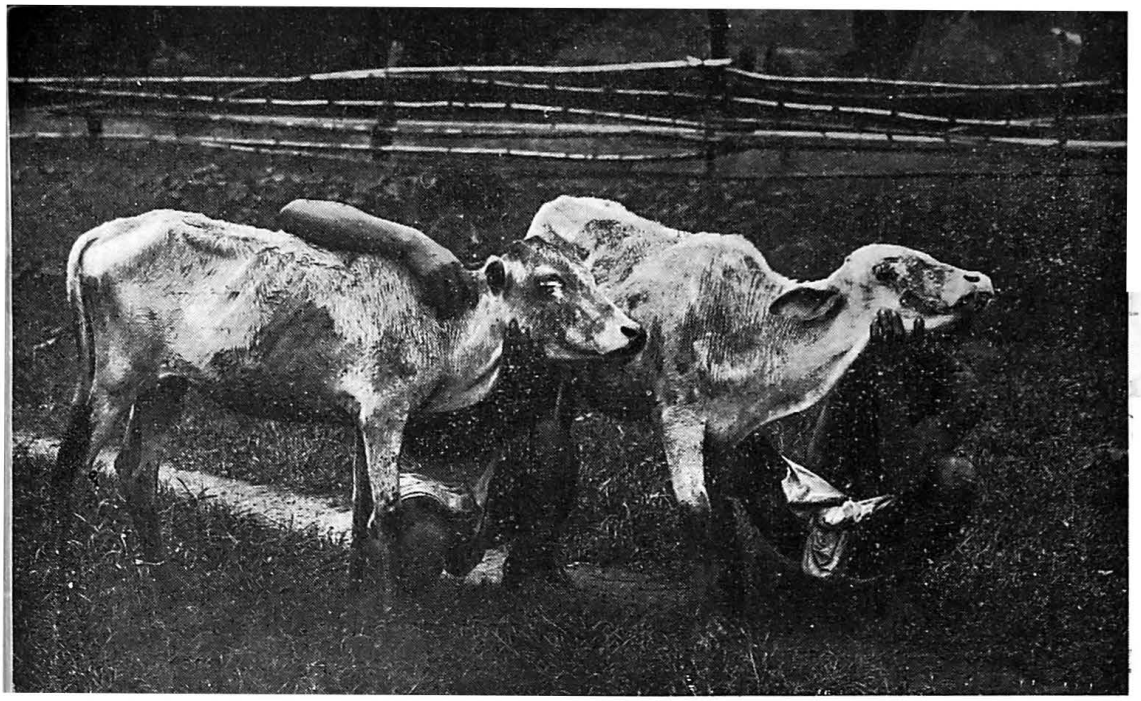
The scope of the work of the Indian Veterinary Research Institute also gradually increased to cover the various aspects of veterinary science. The Institute could now tackle some of the important problems, which it was not otherwise able to handle on financial grounds.

Afterwards a body called the Animal Husbandry Wing of the Board of Agricultural and Animal Husbandry in India, was constituted to provide a common platform for all the workers in the field of animal husbandry and veterinary science to get together once every two years and exchange ideas on topics of varied interests and problems facing the country.

Virus and bacterial diseases

Disease investigation scheme. The scheme for the appointment of Disease Investigation Officers in the various States was sponsored by the Council in 1932. Most of the States have now incorporated the scheme in their permanent establishment. The object has been to carry out a survey of and investigations on animal diseases prevailing in the States, to test under field conditions various remedies and methods of disease control, and finally to recommend suitable steps to put into practice the results of research for the benefit of farmers.

The most serious problem of all-India importance is the effective control of rinderpest. Within a few years of the establishment of the Indian Veterinary Research Institute an anti-rinderpest serum was evolved. The virus was then fixed in goats and the attenuated vaccine made from goat spleen was found to render life-long immunity in the treated cattle. The vaccine was cheap and large-scale immunisation of cattle helped in bringing down the deaths caused by rinderpest by 90 per cent. Recently a still cheaper lapinized vaccine has been evolved which produces practically no reaction in the immunized animal and yet imparts solid immunity lasting for a long time. Accordingly, a 10-year plan for the eradication of rinderpest in India has been accepted in principle by the Government of India. The Food and Agricultural Organisation has also agreed to help in the execution of this plan by deputing experts and supplying necessary machinery for the mass-scale manufacture of the vaccine.



A case of vitamin A deficiency

Preliminary field surveys have been undertaken to find out the extent of prevalence of major bacterial diseases like haemorrhagic septicaemia, anthrax, black-quarter, brucellosis, tuberculosis, Johne's disease and other contagious and infectious diseases. The efficacy of the various biological agents produced at the Indian Veterinary Research Institute is under study in field conditions.

Many obscure disease conditions of undetermined aetiology have also been investigated. Amongst the obscure diseases studied were encephalomyelitis, circling disease, contagious caprine pleuro-pneumonia, etc. The existence of hitherto undiagnosed diseases such as contagious bovine pleuro-pneumonia, rickettsiodis, etc. has been brought to light and attempts have been made to bring them under control.

Poultry diseases. On the recommendations of the Advisory Board of the Indian Council of Agricultural Research in 1937, it was decided to render assistance to each State by enabling it to appoint an officer exclusively for the investigation of poultry diseases. Almost simultaneously, a research officer was appointed and deputed to England for training in poultry diseases. At the Indian Veterinary Research Institute, very useful work has been done in respect of incidence survey of poultry diseases, their epizootology, aetiology and adoption of adequate control measures.

The Ranikhet vaccine from incubated eggs also stands out prominently as a landmark which has made poultry farming in India a safe venture. Surveys have been made in regard to the occurrence of fowl pox, fowl cholera, neurolymphomatosis, tuberculosis, keel disease of ducks and fowl typhoid. In most cases adequate control measures have been formulated.

Investigations on contagious coryza, catarrhal roup, and avian diphtheria are in progress.

Sheep and goat diseases. Some of the diseases of sheep and goats in which investigations and surveys have been carried out are rinderpest, sheep and goat pox, sheep dermatitis, encephalomyelitis, contagious caprine pleuro-pneumonia and other kinds of pneumonias, anthrax, wah, enterotoxaemia and other anaerobic infections. Contagious caprine pleuro-pneumonia and other pneumonias of unknown aetiology have also been investigated and work to evolve a suitable vaccine for effective control of the disease is in progress.

Contagious abortion in cattle. The surveys carried out regarding the incidence of contagious abortion indicated that the disease occurs in nearly all Indian farms and in many rural areas in the form of low grade enzootics, the percentage of infection varying from place to place. Sero-agglutination tests for diagnosis of *Brucella* infection have been standardised and the methods for effective control of the disease laid down.

Tuberculosis and Johne's disease. Preliminary surveys carried out in certain urban areas of the country have shown tuberculosis to be most prevalent in the north-west, less so in the western and eastern States and least in the south. The incidence of the disease in buffaloes has been somewhat higher than in cattle, and buffaloes have been shown to be highly susceptible to artificial infection with the bovine type of tubercle bacilli. Infection in goats is found to be due to the bovine type.

Studies have been shown that pigs suffer from all three types of the tubercle bacillus, *viz.*, the human, the bovine and the avian. Studies have also been carried out to improve the methods of production of tuberculin of approved potency for the diagnosis of the disease.

Johne's disease also has been found to be widely prevalent among goats in certain localities and in sheep. Work is in progress to see if vaccination could be adopted as an effective method for the control of this disease.

Foot and mouth disease. Experimental trials with the crystal violet vaccine have proved that this product as well as its modification, a concentrated vaccine, is quite effective in affording protection to cattle against the foot and mouth disease and the immunity has been shown to last for about 15 months, both under laboratory and field conditions.

Diseases caused by anaerobic bacteria. Studies on aetiology of black quarter and other conditions principally of sheep and goats have been undertaken and methods are underway for the production of improved types of vaccines for controlling the disease.

Sudden deaths amongst sheep are not uncommon in this country and these often go undiagnosed. Some of these have been definitely proved by laboratory examination to be due to enterotoxaemia, a disease of sheep which was not hitherto known to occur in this country.

Lapinised vaccine. The vaccine has proved very useful for the immunisation of highly susceptible breeds of animals which usually show a severe reaction to the inoculation of vaccine prepared from goat adapted virus. Further work is in progress in order to find out if this vaccine could be more economically produced.

Protozoan diseases. Data available show that the monetary loss due to deaths caused by surra amounts to rupees one and a half lakh annually, besides the much greater loss due to the decrease in the working capacity and in milk yield of the affected animals. Antrypol, a British preparation, is used at present for the treatment of the disease, this may, however, be replaced by Antrycide.

Babesiasis. Red water fever in ruminants and horses is caused by host-specific protozoa belonging to the genus *Babesia.* A new species has been discovered affecting the blood of the Indian sheep. *Aegyptianell pullorum* infection in fowls has been shown experimentally as being transmissible through a tick.

Goat showing lesions of pox

Theileriaisis. Investigation at the Indian Veterinary Research Institute, on theileriaisis have revealed that the causative parasite is transmitted by a tick and that the adult progeny of the infected tick are also capable of transmitting the infection.

Coccidiosis. In young poultry, coccidiosis is next to the Ranikhet disease in virulence. Investigations are in progress on the incidence of this disease in sheep and goats, as well as on the pre-disposing climatic factors and susceptibility of different breeds.

Other important protozoan diseases under study are amoebiasis in ruminants and *langurs*, trichomoniasis in pigeons and young poultry, bartonellosis and toxoplasmosis in dogs, and rickettsiosis in sheep and cattle.

Diseases caused by parasitic worms

Systematic investigations have brought to light a number of disease conditions, the causes of which were not known before, but which have now been shown to be of purely helminthic origin. Quite a good number of new worms of economic importance have been discovered and described from a variety of hosts in India.

Among the important helminthis diseases of ruminants may be mentioned "Liver rot" by liver flukes causing cirrhosis and oedematous swellings; "Snoring disease" "Gid" "Hydatid" "Pimply gut" "Hust" or verminous pneumonia; "Hump sore" and "Blood boils".

In equines, liver affection has been found to be caused by *Schistosome* resulting in nodular portal cirrhosis. Some other helminthic diseases in equines are strongylidosis caused by *Strongyles* bringing about aneuryams of the mesenteric artery, volvulus and colic, "Bursati" caused by Habronema larvae causing chronic-inflammation of the cutis and sub-cutis, and "Lichin tropicus" caused by *Microfilariae* producing dermatitis. Taeniasis caused by tape worms resulting in unthriftiness, emaciation and nervous symptoms and ancylostomiasis caused by hook worms producing anaemia and oedemas are common in carnivora. Flukes affect the oviduct in poultry interfering with the mechanism of egg production. Teaniasis caused by tape worms producing intestinal nodules, retarded growth and reduced productivity and "Gape" by *Syngamus* causing dyspnoea, asphyxia and death are some of the other helminthic diseases in poultry.

Deficiency diseases

The attention of scientists had been drawn to the necessity of studying the effect of malnutrition on health, productive capacity and disease susceptibility of animals. With the initiation of disease survery in different States, a number of deficieny diseases have been found to be commonly prevalent. A quantitative deficiency of digestible proteins in the ration is widely prevalent in many parts of India where straws form the main feed for several months in the year. A dramatic increase in the body weight of calves in the Malabar and South Kanara districts of Madras, took place when balanced ration was supplied to these animals.

Vitamin deficiencies. The first symptom of vitamin A deficiency is night blindness. This usually occurs when livestock are deprived of green fodder for 6-8 months. In the more severe form, the deficiency of this vitamin is reflected in the occurrence of blindness, debility in the hind limbs, and death of the new born calves chiefly through pneumonis or other respiratory diseases.

A few cases of ploy neuritis in fowls were reported from Mukteswar which might be due to vitamin B deficiency. Provision of yeast and whole grain cured the symptoms promptly. No further cases have been reported as yet from any other part of the country.

The occurrence of rickets among domestic dogs and pigs due to vitamin D deficiency is known in India. At Mukteswar one bitch consistently produced rickety pups. The symptoms could be relieved by giving cod-liver oil to the pups, but not to the mother.

Mineral deficiency. Supplementation of feed with mineral mixture has been reported to have checked the occurrence of abortion in mares at the Army Stud Farm in Ahmednagar and in cows at Palghar in Bombay. In both the investigations, a low calcium content in the blood of the animals was found before treatment.

Investigatons at Izatnagar have revealed a deficiency of essential trace elements like copper, cobalt and manganese in many of the common Indian feeds. Addition of a trace element mixture to the usual rations resulted in increased growth rate of calves and milk production in some cases.

an adult animal has revealed that the requirement of these minerals depends not only on the body weight but also largely on the nature of the ration.

In addition to these major mineral elements, work at Izatnagar has established the maintenance requirement of such trace elements as copper, cobalt, magnesium and iron. Examination of typical feeds have revealed that many common rations at certain parts of the year may be deficient in these essential trace elements.

As a result of these investigations, a trace element mixture has been developed which is being fed as an exploratory measure at a few Government Dairy Farms. Observations extending over the last two years show that the supplementation of this mixture helps in augmenting milk yields and in reducing inter-calving periods.

Vitamin requirements

A complete mineral mixture, which includes calcium, phosphorus and common salt, besides trace elements, has been developed and has been advocated for use all over the country.

Work carried out at Izatnagar has established the vitamin A requirement of normal adult animals. Some investigations have also been carried out to show that the vitamin A excretion through milk is proportional to the intake of this vitamin. During late winter and summer, when green fodders are not available, the intake of vitamin A and its concentration in milk is greatly diminished. Experimental work on sheep has shown that if the diet is kept sub-adequate with regard to vitamin A, the growth of the body is retarded and the yield of wool is poor.

Species difference

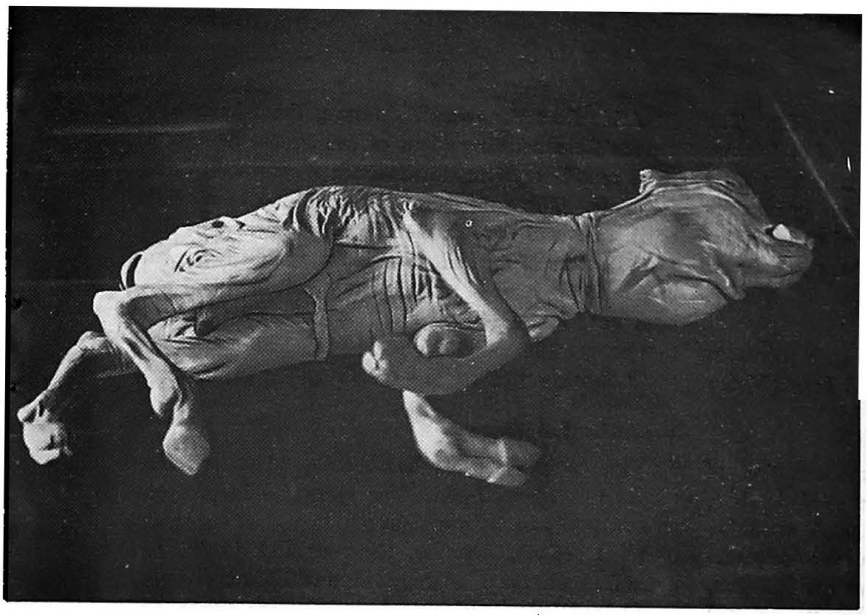
Investigations at Izatnagar have revealed that the digestibility coefficients of food nutrients are similar in cattle and buffaloes but as the dry matter consumption of the latter species is higher, they can maintain themselves much better on coarse fodders. Similarly the dry matter consumption per unit of body weight is much higher in sheep and goats. The requirement of protein, calcium and phosphorus for sheep are also relatively higher.

Subsidiary feeds

It has been calculated that the average supply of digestible crude protein and energy in the country is 23 per cent and 38 per cent of the required amount. These figures reveal that malnutrition is the greatest single factor for the degeneration of cattle in India.

Wild grasses like kans (*Saccharum spontaneum*), *munj* (*Saccharum munj*) have been found to form a maintenance ration by themselves when cut at the pre-flowering stage. When conserved at this stage they form a palatable silage. Even at the ripe stage these grasses when mixed with molasses can be fed profitably. Similarly *kantiara* (*Carthamus oxycantha*), a thorny shrub, can be fed as a better class roughage if the leaves are dried and the spikes present are beaten out by a flat rod.

Treatment of paddy straw in cement tanks with dilute alkali or water improves its quality



Goitre in goats is commonly met with in the sub-Himalayan ranges

Mango seed kernel, *jaman* seed, crushed tamarind and accacia seeds, fish meal, entrails from slaughter houses, *Cassia tora* seed and rain tree fruit can be utilised to supply valuable concentrates. Long range experiments have shown that they can be fed to milch, growing and draft animals with advantage.

Besides these, sugarcane tops, *mahua* flower, *bajra* and *jowar* husks, tapioca, etc., which have high available energy content, can be fed profitably to working bullocks.

Tree leaves as fodder

Leaves from trees like *paker*, *gular*, *neem*, *katchnar*, *dhanni*, *morarfali*, etc. have got very good nutritive value, and many of these can provide succulent feed rich in vitamin A, when green grasses or cultivated fodders are not available.

Conservation of fodder

Conservation of fodder is a practice practically unknown to the common cultivator in India.

It has been found at Izatnagar that good silage can be produced in a small pit, easily dug and filled by two men in 4-5 days. One such pit will provide enough feed for two bullocks for two months. Tree leaves after shedding, when mixed with berseem or lucerne and ensiled, give a palatable feed which can form a maintenance ration. It also helps to convert a waste substance, *viz.*, shed tree leaves, into a livestock feed.

Processing of coarse fodders

It has been found at Izatnagar that through treatment with dilute alkali the nutritive value of the straw can be considerably improved. It also appears that when alkali treated straws form the roughage, less amounts of concentrates are required to keep the animals in nitrogen balance. Moreover, this treatment completely removes obnoxious principles like oxalic acid and potassium from paddy straw.

Blood composition of farm animals

Systematic work carried out at Izatnagar has enabled the workers there to compile the data regarding the morphological and chemical make-up of the blood of normal cattle, buffaloes, horses, sheep, goats, etc. under different physiological conditions such as lactation, growth, etc. as also in the case of resting as well as working adults. It has been found that in breeds within a species or even in one breed under different climatological conditions, the concentration of many of the substances present in blood may differ significantly.

Toxic plants and minerals

No statistics are available in India as to the number of livestock dying each year through ingestion of poisonous plants, but it is reasonable to suspect that their number is quite high and that most of the deaths for which no cause can be ascribed are due to plant poisoning. Thus young *jowar* plants, Johnson grass, maize plants, *kodu* grass and star grass have been found

to contain appreciable quantities of cyanides. The concentration of this toxic substance is found to decrease as the plant matures and very little is present after the flowering stage. A new method of curing cyanide-rich plants like *jowar* has been discovered at Izatnagar by ensiling the material for about three months or drying it in sun for a fortnight.

The toxicity and the lethal doses of such poisonous plants like Rhododendron, *datura* and *kaner* (*Nerium odorum*) have been established.

Among toxic minerals a high concentration of fluorine has been found in the well water at Hyderabad, Madras, Madhya Bharat, Baroda, etc. A condition of chronic fluorosis in man and animals is widely prevalent in these areas. The symptoms are stiff gait, lameness, debility and even death among the afflicted stock. When the phosphorus supplement like bone-meal was simultaneously fed, the affected animals could be kept in working condition for several years. Addition of ammonium sulphate or a mixture of iron, copper and cobalt salts was also efficacious in checking the deterioration of animals ingesting a large quantity of fluorine.

Deficiency disease

It has been stressed before that the average Indian cattle is semi-starved and thus chronically suffers from general malnutrition. This is reflected in its short stature, poor growth, low milk production and incapacity for sustained work. In Malabar as well as in Orissa, it has been found that the introduction of a balanced ration increases the productive capacity of cattle.

Aside from the overall shortage, there have been reports from certain regions of deficiencies in one or more specific nutrients in the feeds of even well cared for cattle. These nutrients are generally some minerals or vitamins and their deficiencies in a feed may be due to the nature of the soil on which the plant is grown, or due to the stage of maturity at which the plant has been cut for feeding. Work at Izatnagar showed that many common fodders may be deficient in essential trace elements like copper, cobalt and manganese.

Vitamin deficiency

Vitamin A deficiency has been found to be widespread throughout India. The symptoms in progressive order of severity are night blindness, birth of weak or blind calves, sterility, blindness and death. As green feeds are the usual source from which this vitamin is obtained by a ruminant, these deficiency symptoms are usually prevalent in those seasons when such feeds are scarce. Carotene as present in leaves is easily destroyed after the leaves are plucked but can be preserved for long periods if such leaves are quickly dried and the dry product kept in sealed containers.

Nutritive value of vanaspatis

It was found that with sub-adequate dietaries prevalent in most regions of the country, prolonged replacement of *ghee* by vegetable oils, raw, refined or hydrogenated, is likely to lead to adverse effects such as decreased growth, higher vitamin requirement, lower calcium, phosphorus absorption, etc. However, when the deficiencies of the basal dietaries are removed and the rations made liberal in all essential nutrients, the difference between cow *ghee* and the vegetable oils or *vanaspatis* tend to disappear.

Dairying

by

K. C. Sen

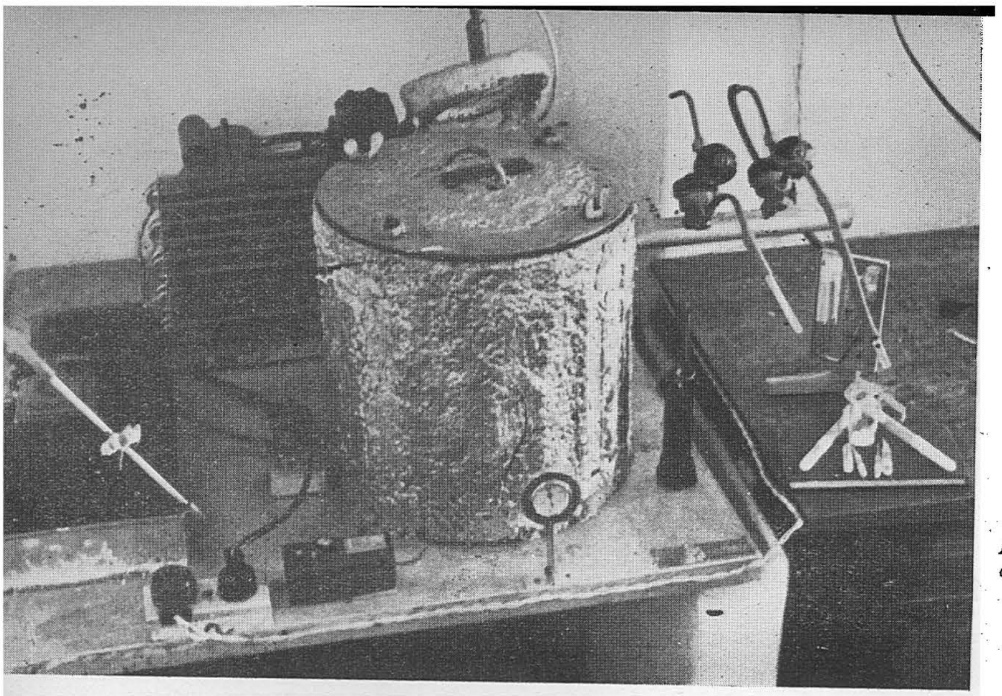
PRIOR to the establishment of the Indian Council of Agricultural Research in 1929, some amount of spade work had no doubt been carried out in the fields of cattle breeding, animal nutrition and milk production. For example, the Military Dairy Farms had made attempts to improve the milk yield of Indian cows by crossing them with imported European bulls and had also introduced several modern dairy techniques in their operations. The famous Pusa herd of Sahiwal cattle had been developed at the Indian Agricultural Research Institute while the Animal Nutrition Section at Bangalore and in some other places had made pioneering contributions in the fields of animal nutrition and livestock feeding. The Indian Dairy Research Institute at Bangalore, which was established in 1923, was giving training to dairy technicians and also providing technical advice to the dairy trade. The Dairy Institute at Bangalore commenced the work of developing pedigree herds of Sindhi and Gir cows and Murrah buffaloes in 1933 and a few years later, it was also equipped with facilities for carrying out research work in dairy science.

Dairy husbandry

The low productive capacity of Indian cattle, caused by years of indiscriminate breeding and under-nourishment, has constituted a major difficulty in the way of increasing milk production in the country. Primary attention has, therefore, been devoted to this aspect of the problem and the various dairy development schemes and programmes undertaken during the past 25 years. With a view to stimulate interest in cattle development work and encourage the farmers to adopt improved methods, a number of steps have been initiated, *e.g.*, formation of breed societies, organisation of milk recording schemes, definition of breed characteristics of important breeds, establishment of Central Herd Books for registration of approved animals of recognised breeds, and organisation of cattle fairs and all-India cattle shows. Cattle breeding farms have been established in several parts of the country with a view to conserve and improve better breeds of cattle and as a result of selective breeding, scientific management and proper feeding, pedigree herd of most of the well-defined milch or draught breeds of Indian cows and buffaloes have been developed. Experiments have also been conducted to evolve a "dual purpose" type of animal, to improve the milk yield of draught breeds and to study the possibilities of using milking cows for draught purposes.

Experiments on cross-breeding of Indian cows with imported European bulls revealed that while the first crosses gave striking increase in milk yield, continued introduction of foreign blood had an adverse effect on the health and constitution of the animals. Since such cross-breeding has not been found suitable for general adoption in the country, greater attention has been focussed on the use of Indian bulls of high milking potency for grading up village cattle. In order to speed up this work and in view of the paucity of good bulls in the country, a number of key village centres, equipped with facilities for providing artificial insemination services and for giving technical assistance to the farmers, have been established near important breeding farms throughout the country. Field trials on the application of artificial insemination have given very encouraging results.

Schemes to study the problem of degeneration of cattle in hot and humid regions, as also the physiological genetics of Indian breeds of cattle under adverse environmental conditions have been sponsored in West Bengal. Other investigations that have been carried out in this connection are studies on the heat tolerance of Indian cows and buffaloes; use of various oestrogenic hormones for initiating lactation in heifers; pre-milking influence of various factors on the gestation period of cows and birth weight of calves; and problems connected with the preservation and transport of bovine semen under Indian conditions.



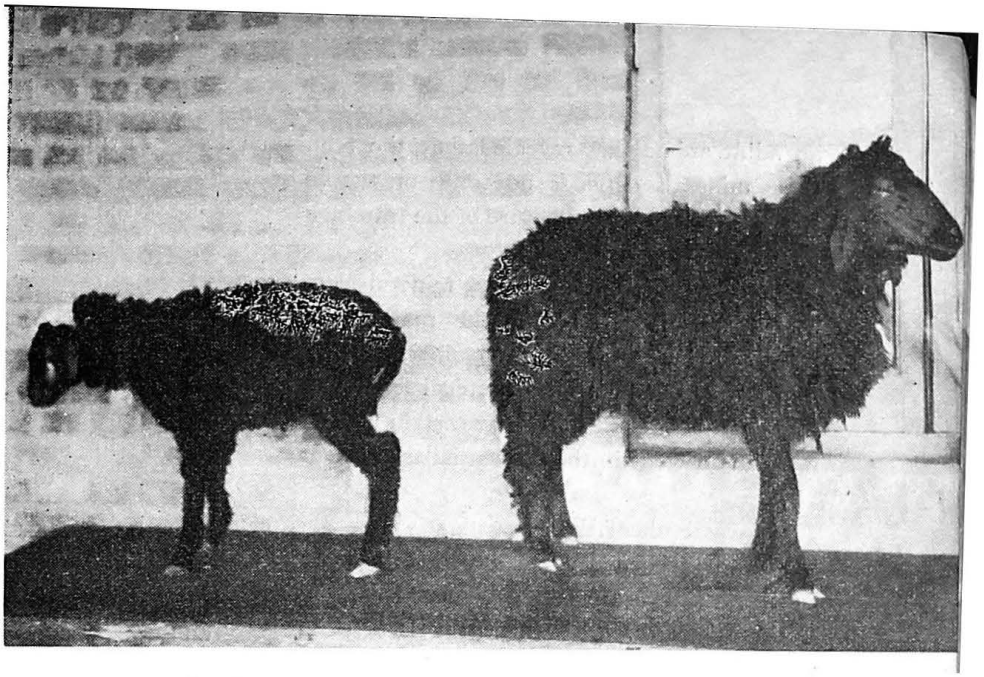
Equipment for freeze-drying dahi bacteria

Sindhi cows at work

Animal nutrition

by

N. D. Kehar



Lambs of the same age. (Left) Given vitamin A deficient diet. (Right) Given normal diet.

THE common feeds for livestock in India can be classified as follows: (1) straws, (2) bye-products of human food such as oil cakes, brans, hush and *dal chunies*, (3) grains like gram, barley, oats and (4) cultivated fodders like *jowar*, miaze, etc. Besides these, the animals get grazing for 3-5 months in the year, when monsoon grasses are usually available. Feeds, which contain appreciable quantities of all essential food ingredients and which are low in fibre content, are recognised to be of high quality. Judged by these criteria, straws which form the bulk of livestock feed in India are of the poorest quality, whereas grains and oil cakes are excellent.

In was found that the chemical composition of any particular feed would be subject to many determining factors like the soil in which it was grown, availability of water, the strain of fodder plant used, temperature, the stage of maturity of the plants, etc. For these reasons the chemical composition of feeds from different parts of India had been found to show large variations. In order to get the maximum yield of essential feed nutrients, it would appear that grasses and legumes should be cut just before flowering.

Nutritive value of feeding stuff

In order to assess the nutritive value of a feed, digestibility experiments should be conducted to find out the extent to which the different nutrients present in the feed are utilised by the animals.

It may be mentioned that the nutritive value of most of the common roughages and concentrates has been determined. Straws are the worst fodders, though *jowar* and *ragi* straws have slightly better digestible proteins and energy contents.. Green fodders have excellent nutritive values though such values diminish quickly as the plants become more mature. Legumes like berseem have high protein content and investigation have shown that berseem hay can replace 50 per cent of the concentrate mixture without affecting the growth rate of calves or milk production in cows.

Nutritive requirements

The results of work carried out so far indicate that the energy requirement for maintenance of Indian cattle may be 30-40 per cent less than the Morrison Standard. Similarly the digestible crude protein requirement for maintenance in Indian animals is also 25 per cent less than foreign standards. An interesting observation made at Izatnagar is that when sufficient energy yielding nutrients like carbohydrates and fats are supplied in the ration, there is no need to provide extra protein for muscular work. As protein-rich feeds are the costliest items in a ration, this study has made possible the provision of much cheaper rations for working bullocks.

Mineral requirements

Work carried out a Izatnagar on the requirement of calcium, phosphorus and magnesium, for maintaining

Some of the important animal nutrition studies carried at are: studies of the nutritive value of the common livestock feeds in the country; nutritional requirements of different classes of animals and of computation of balanced rations with available materials; methods of fodder conservation; improvement in the feeding value of straws by alkali treatment; and utilisation of waste plants and bye-products as cattle feeds.

Dairy technology

Problems connected with the economic production and disposal of milk in the villages and improvement of market milk supply have received considerable attention. Some of the important laboratory and field investigations carried out in this connection include simple methods of cleaning and sterilizing dairy utensils, use of hydrogen peroxide for increasing the keeping quality of milk; and costing of various operations involved in the production of high quality milk. An alternative method to refrigerated transport, involving the intermittent heat-processing of milk, has been developed and found useful for transporting milk over long distances. A tamper-proof can for retail milk distribution has also been fabricated. With regard to *ghee*, important investigations which have been carried out in this connection include: causes of high acidity in market *ghee* and its neutralisation by treatment with lime; methods of keeping quality of butter and *ghee*; use of insulated hay-box for preserving milk in a hot condition; comparison of different methods of *ghee* making and standardisation of the methods of manufacture of creamery and *desi* butter and *ghee*. An improved method of *ghee* manufacture by pre-stratification of butter has been devised.

Other indigenous milk products which have been studied are *dahi*, *khoa*, *chhana*, Surati cheese and lactic casein and improved methods of manufacture and conditions of storage of these products have been standardised. Investigations have also been conducted on the utilisation of skim milk and butter-milk for manufacture of industrial casein, preparation of crude lactose from whey, use of *ghee* residue in edible preparations, preparation of condensed and dried milks and use of plant enzyme preparations as substitutes for animal rennet in the manufacture of cheese.

Dairy bacteriology

Among the type of organisms contaminating market milk, coliform bacteria and lactic streptococci have been found to be most important, and unclean utensils form the major source from which they gain entrance to milk. Another research project has recently been undertaken to study in detail the numbers and types of heat-resistant bacteria occurring in market milk with a view to obtain basic data for determining suitable heat-processing temperatures for Indian milk.

A qualitative survey of the types of *dahi* produced in different parts of the country has been made, and from a detailed study of the lactic acid organisms isolated from them, suitable starters have been prepared for use in the preparation of good quality *dahi*, butter, fermented milk and cheese.

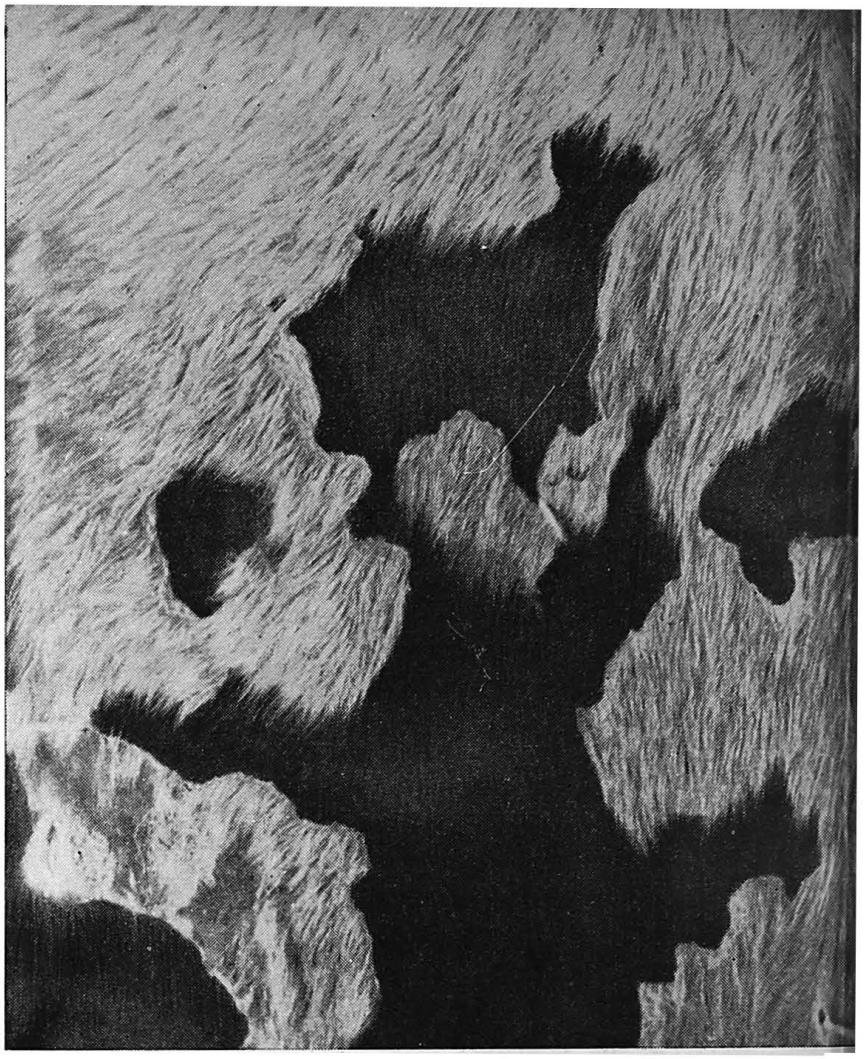
Dairy chemistry

The differences in the chemical composition of milk of cow, buffalo, goat and sheep, and the variations due to breed, stage of lactation, season and other factors have formed the subject of extensive investigations. Detailed studies have also been made to obtain information on the nitrogen distribution, calcium and vitamin contents, enzyme activities and various minor constituents in the milk of different species and the influence of souring, heat-processing and other factors on the composition of milk.

Hides & Skins

by

B. N. Soni



A picture of hide damaged by the hide beetle

ACCORDING to post-war information, India possesses more than 30 per cent of the world's cattle and her estimated production of hides is between 15 and 20 per cent of the world's production. Although India's production of goat skins is also estimated to be very high, her position in the world market in regard to this commodity is considered by experts to be somewhat stronger than in the case of hides.

Even after partition, India maintains her supremacy in the world market in regard to these commodities and is even in a position to spare a big surplus for export. Her position as an exporter would have been even stronger were it not for the fact that the defective quality of Indian hides and skins, on account of damage caused to them by biological factors, often accounts for either their total rejection or depreciation to the extent of 50 to 60 per cent of their value when graded in foreign markets.

It has been further computed that the raw stock is depreciated to the extent of not less than one-tenth of its value as a result of damage caused to it by warble flies (*Hypoderma lineatum* and *H. crossi*) and ticks. Ticks and the Leather Beetle, *Dermestes valpinus* have also to be reckoned as the more important biological factors causing damage to hides and skins in India.

The ox warble fly

Results of the surveys carried out during the course of this investigation have shown that the ox warble fly (*H. Lineatum*) is widespread in the northern and norther-western India. *H. Lineatum* deposits its eggs usually near the hock and on the inside of the legs, the total number of eggs laid by a single fly ranging from 200 to 500 under Indian conditions. The eggs hatch in about 4-6 days and the newly hatched larvae penetrate the skin and migrate through the body until

eventually they reach the back of the animal, and there they form a warble tumour through which they pierce a hole for breathing. The warble tumours usually appear in "crops" on the back of the host, at intervals of about a month, during a period of four months from October to January. Observations have shown that the pest is also responsible for loss of condition and for a reduction in milk yield.

Periodic singeing of hair on the legs of the cattle during the egg laying season, namely from mid-March to mid-June has been found to be the only practical method of destroying the eggs on a large scale. The singeing is best done at intervals of 5-6 days.

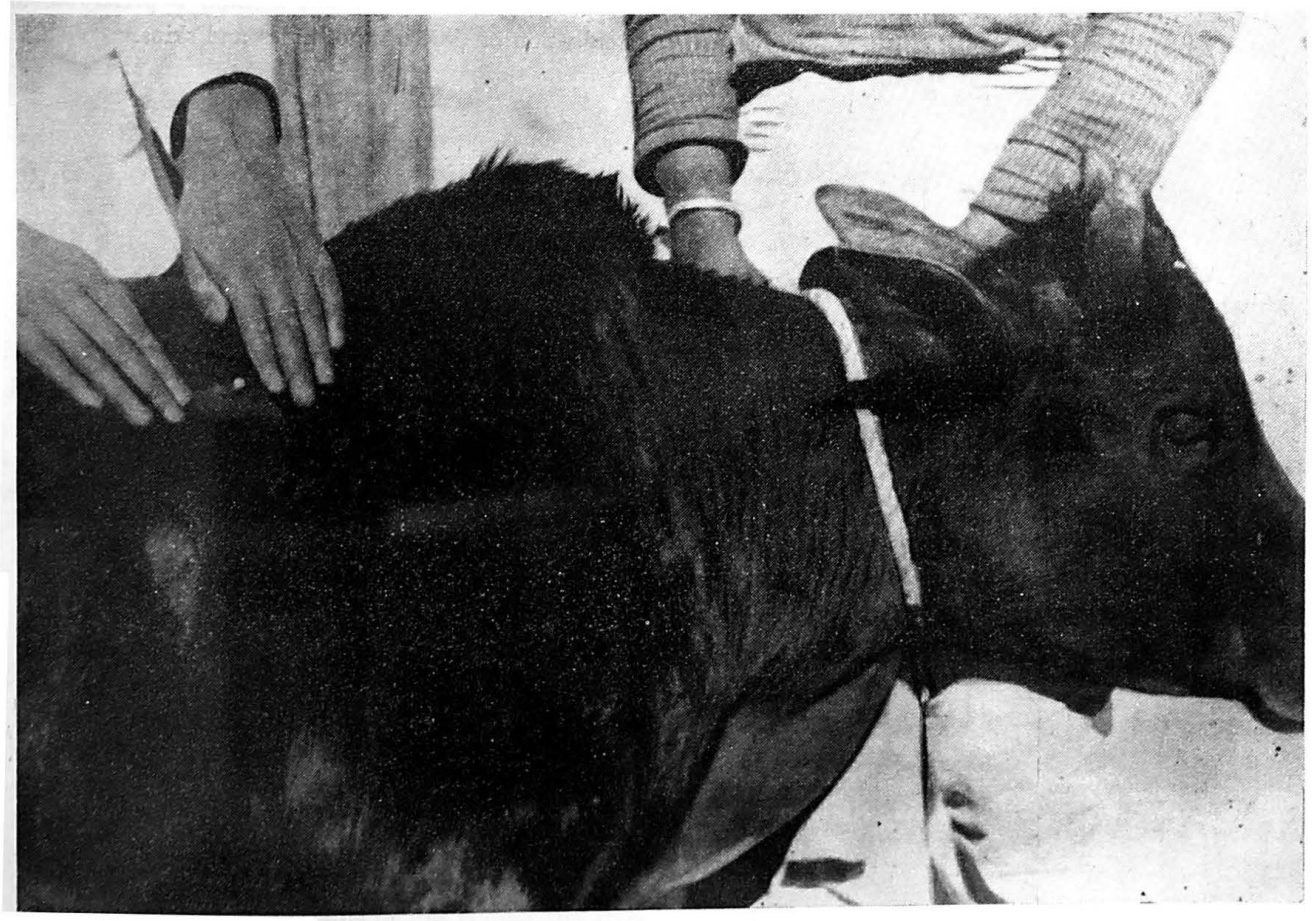
The application of larvicidal dressings on the warble tumours is now regarded as the method of bringing about a progressive reduction in the incidence of the warble fly pest, although it is obvious that such methods cannot repair the damage already done to an animal. The dressings commonly used are: (1) a mixture of tobacco powder and lime, and (2) derris powder; under Indian conditions dressing operations should commence in early October and continue till the end of January at monthly intervals.

The goat warble fly

This serious pest of goats still awaits detailed investigation. It has been found that warbles containing larvae of this pest (*H. crossi*) appear on the backs of goats during the months of July to January. The goat warble fly is prevalent throughout Punjab, Kashmir, Uttar Pradesh, Rajputana and the neighbouring localities.

Ticks

The smaller but much more numerous pit marks made on the skin by ticks, though less obvious, are actual punctures in the hide substance. The grain of the hide is in consequence damaged and the tanned leather is weakened and spotted. A large proportion



A warble grub being squeezed out of an animal's back

of chrome leather now produced in India is finished with the grain left on, so that all such tick marks on the grain side show up very plainly.

During recent years, DDT and Gammexane have been brought into use in the field of tick control on account of their non-poisonous properties and superior tickicidal value. Both these drugs have been subjected to a series of trials and have proved highly effective against the common species of cattle ticks occurring in India. It was found that DDT powder made into an emulsion with kerosene oil and liquid soap to a concentration of 0.5 to 1.0 per cent destroyed ticks at all stages within a short time. Results obtained with Gammexane powder showed that within 24 hours of its application, tick mortality varied from 75 to 95 per cent on the treated animals and that after a period of 48 hours all the animals were tick free.

One obvious advantage of DDT and Gammexane over arsenical dips is that the introduction of the latter into rural areas involves an element of risk on account of their well-known poisonous properties.

Leather beetle

The leather beetle (*Dermestes vulpinus*), also known as the hide beetle, causes damage during storage of the raw stock and the monetary equivalent of the damage is by no means negligible.

Observations have shown that the beetle breeds profusely under warm and moist conditions such as those provided by storage of hides and skins for long periods. The incidence and intensity of the damage is higher in "dry cured" hides and skins than in those which have been preserved under "wet salted" condition. The larval stage of the beetle causes more damage than the adult stage. The damage done by the insect is more on the "flesh side" than on the "grain side" of the hide or skin. The insect prefers to feed on folded hides and skins rather than on those that are left unfolded.

Tests carried out under laboratory conditions have shown that Gammexane powder at a concentration of 2.5 per cent in talc powder, when dusted to form a thin film on the "flesh side" of hides or skins, causes a mortality of 85-90 per cent among the larvae and confers protection from re-infestation by the parasite for a period of about 30 days. Because of its non-toxic properties to human beings, this method is preferable to arsenication or poisoning of hides and skins.

Sheep

by

S. S. Khot

Depth of staple in Patanwadi sheep

SHEEP rearing forms an important feature of the rural economy of this country. Wool as an article of trade and industry is known to India from ancient times. The cloth prepared from the fleeces was considered sacred and is still worn at the time of devotion. There are 38 million sheep, producing approximately 44 million lb. of wool per annum, the total estimated production being valued at Rs. 9 crores. Out of the total clip, 38 million lb. are annually exported bringing an income of Rs. 8·1 crores in foreign exchange. As an exportable agricultural commodity, wool occupies the eighth position. Simultaneously this valuable raw product helps the country in giving occupation to thousands of spinners and weavers. Sheep also contribute towards the supply of nutritious food in the form of meat worth about Rs. 11·2 crores each year, in addition to the manure, kinds and pelts, the value of which has not been accurately estimated. Sheep rearing is generally in the hands of nomadic shepherds.

Wool as a raw product is exported from India since 1836, and large-scale industries have been developed in Britain and the United States to utilise the same for the manufacture of carpets. As the country has not developed the sheep for the production of fine wools, it has to import annually large quantities of apparel wool required by the mill industry. It is estimated that 15·75 million lb. of wool, tops and yarn was imported in 1953. Estimated at the lowest cost of Rs. 7-8-0 per pound, the value of this commodity from abroad costs the country Rs. 11·8 crores. This will show that a lop-sided economy has been developed in the country, as far as the manufacture of woollen goods are concerned. On one side, the major portion of the raw product is exported, and on the other hand large quantities of fine wool are imported. Further, the indigenous wools are hairy, coarse and of mixed composition as far as the staple is concerned. The fibre composition, in the so-called selected breeds of the major sheep rearing areas of Rajasthan, Saurashtra and Cutch, is extremely variable, and specimens yielding superior wools and very coarse types are seen in the same region. Similar types of wool quality exist in the vast sheep rearing areas of the Himalayan region, including the States of Kashmir, Himachal Pradesh and Uttar Pradesh. Large flocks of sheep raised on the Deccan plateau yield coloured and coarse fleeces used entirely for the production of *kambals*.

Wool improvement

Considering the undeveloped state of the sheep industry in the country, pilot experimental projects were undertaken by the Council in 1938 and continued up to 1947, at Hissar in Punjab and at Poona, in

Bombay. Simultaneously experimental flocks were maintained in livestock farms in Mysore and Madras States. The work undertaken at these places remained in the empirical stage during the war as the Indian Council of Agricultural Research was not in a position to expand the scope of the work. A small exploratory trial of rearing of exotic sheep was also initiated in Kashmir during this period.

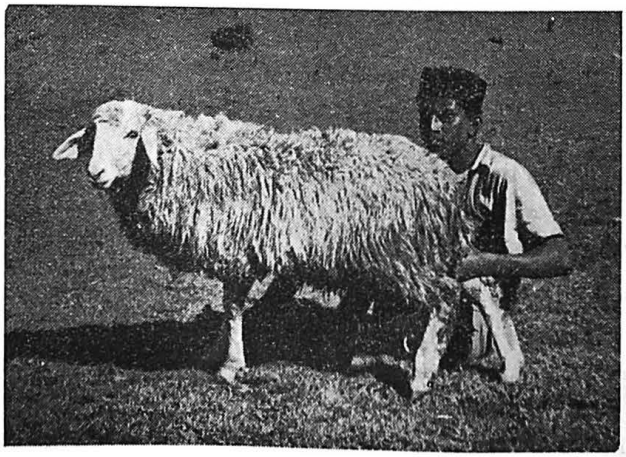
The problem dealt with at the research stations was to study whether the wool quality could be improved by selective breeding or alternately by cross-breeding with the imported Merino rams. The grading of the hairy sheep of Bellary district of the south Deccan with the rams of Bikaneri breed was tried at the Hosur farm. The preliminary experiments have shown that by selective breeding, the hair content of the fleeces can be reduced appreciably and it will be possible to evolve an all-wool yielding sheep, the product of which can be used for the manufacture of tweeds and hosiery.

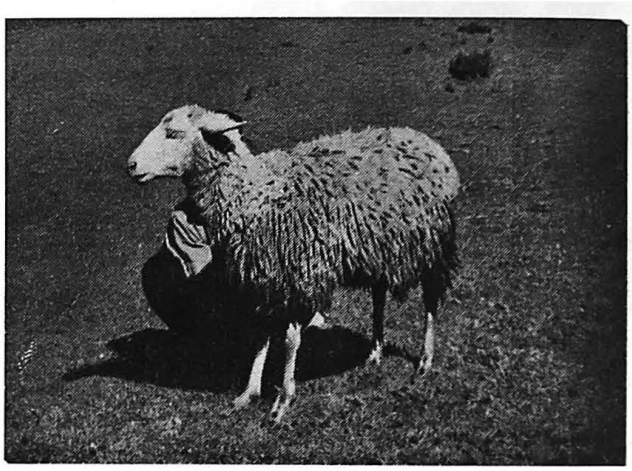
The average Deccani sheep, yields a coloured coarse wool, the diameter of which ranges from 50 to 70 microns, with a hair percentage varying from 60 to 80. By selective breeding, flocks yielding fleeces free from hairiness, and having a diameter of 26 microns, can be evolved. The quality of wool from the hill regions of Uttar Pradesh can be improved by selective breeding to yield an all-wool composition of 50's to 56's spinning quality. The Joria sheep of the southern dry region and selected Bikaneri flocks can yield non-hairy wool with a diameter ranging from 25 to 31 microns.

Cross-breeding

The cross-breeding with the Merino is possible in the areas with higher elevation and cooler climatic conditions. The wool clip from the resultant progeny can be utilised for the production of high-grade woollen apparel.

Nilgiris ram





Nilgiris ewe

As a result of cross-breeding, the Deccani ewes with the Merino, the half-bred animals yield fleeces of the 56's to 62's quality. By further grading, it is possible to get progeny yielding non-hairy fleeces with a diameter as low as 21 microns, reaching approximately the quality of the Merino, fetching thrice the price of the local Deccani wool. The experimental breeding in the hill areas has also shown that the production of fine-woolled fleeces is possible. The half-bred animals yield fleeces of the 58's spinning quality. The progeny with seven-eighths Merino blood have fleeces of the quality above 80's with an average diameter of 16 microns. The cross-bred fine-wools can be valued at five times the price of indigenous wools.

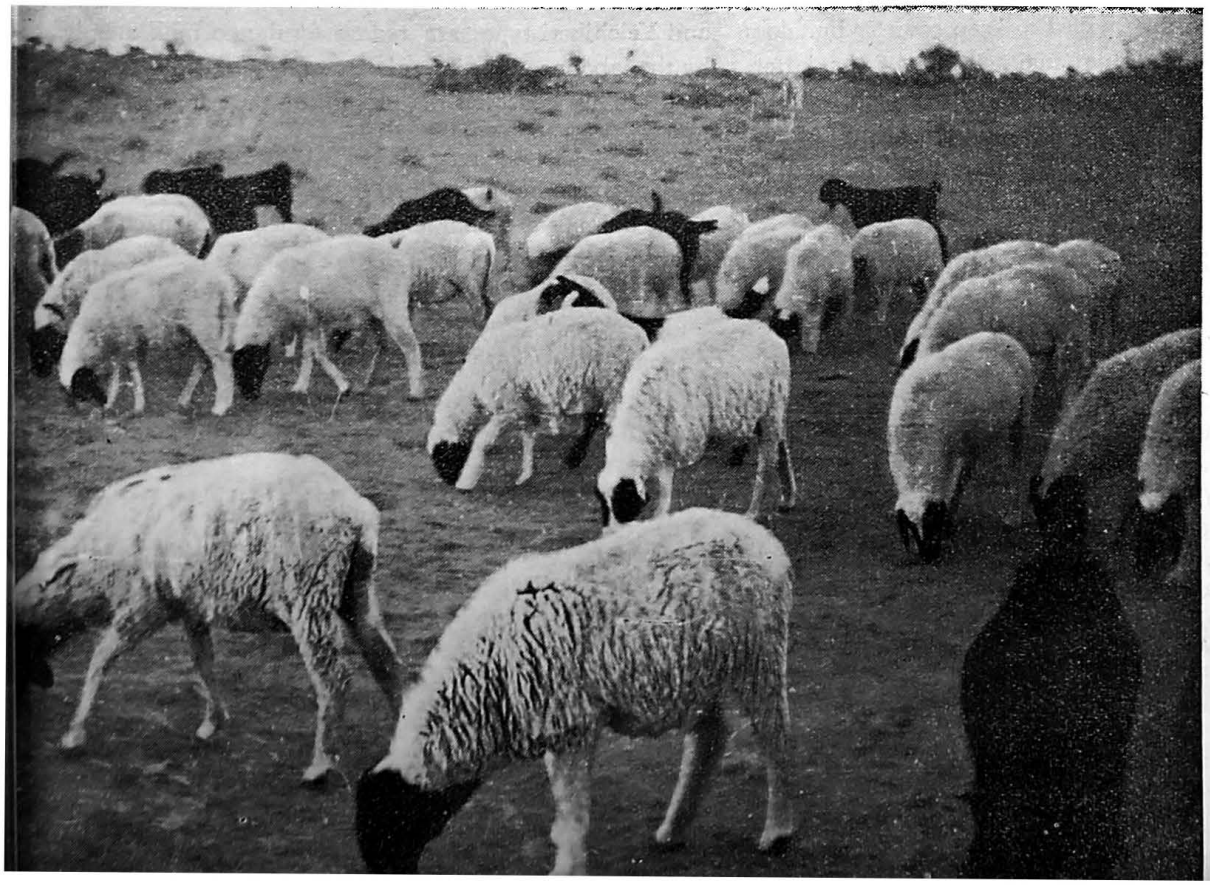
Plan for sheep improvement

With the experience gained from the exploratory trials in sheep improvement as stated above, the Council decided that a comprehensive plan for the development of sheep industry should be undertaken on regional basis. For this purpose, the sheep raising areas of the country are grouped under the following three principal regions:

(*i*) The Temperate Himalayan Region comprising the hill districts of Uttar Pradesh, Himachal Pradesh, Punjab and Kashmir; (*ii*) the dry northern plains comprising Saurashtra, Rajasthan, North Gujerat and parts of Uttar Pradesh and Punjab, and (*iii*) the southern region comprising Bombay, Deccan, Mysore, Hyderabad, Madras and parts of Madhya Pradesh.

The establishment of a full-fledged sheep and wool research centre in each of these regions is under way; there will be sub-stations in the neighbouring areas. These stations are charged with the task of evolving new strains of fine-woolled sheep which will produce heavier fleeces. They are required to supply rams for sheep development work in the rural areas. They are also to investigate into the problems of sheep husbandry, to help the developmental programme among the existing flocks and to introduce sheep rearing in the mixed farming economy. Other functions are to record the wool quality of the experimental flocks and to advise the public as regards the selection of breeding stock, as well as to study the economics of production of wool and woollen apparel.

In this enterprise, different States have initiated research programmes, by establishing sheep breeding farms. Detailed technical plans have been drawn up and a definite line of approach to the problem of sheep improvement has been assigned to each research station. The selective breeding among the existing breeds of sheep to produce finer, non-hairy and heavier fleeces is underway in certain areas of Rajasthan, North Gujerat, Saurashtra and Cutch. The breeding of superior fleeced sheep by cross-breeding with the Merino is in progress at the research stations in Kashmir, Uttar Pradesh and Bombay. Each research station, simultaneously deals with the problem of developmental research in rural areas, studies the adaptability of new types and undertakes multiplication of the superior stock. The Council, with the experience gained in rural areas, has laid down a programme of sheep and wool development in the country on the lines of the Key Village Scheme for cattle improvement, so that tangible results can be achieved within a short period. This project has been drawn up to initiate sheep improvement in 230 centres in different States and among a sheep population approximating to 11½ lakhs of sheep. This will enable each State to convert the centres ultimately into rural stud ram producing units for large-scale sheep improvement drives, which ultimately will help the country in achieving self-sufficiency as far as the raw wool production is concerned.



Marwari flock

Goat

by

S. S. Khot

Gadi buck from Himachal Pradesh

THE goat is a poor man's cow and is the principal source of meat supply in this country. The total number of goats in India is 470 lakh heads and, considering the goat population in the world, India has one-fourth of the total number. Uttar Pradesh has the largest number followed by Madras, Bengal and Bihar. The goat milk is popular among the classes who cannot afford to keep cows or buffaloes due to the higher cost of maintenance of the latter. It is estimated that annually about three lakh heads of goats are in demand for human consumption. Almost all the adult she-goats yield milk either in small or large quantities and thus the animal is of utmost importance in the rural and urban areas forming the main source of subsistence to thousands of goat keepers, besides contributing substantially to hair and skin trade in the country.

Types of goats

Broadly, there are four types of goats in India, (*i*) The Himalayan goat which migrates from the low altitudes to the higher Tibetan plateau and to grazing grounds of many intermediate heights. They are also found in the arid regions of Kashmir, Punjab and Uttar Pradesh. The best variety in this group is the Chamba goat of Himachal Pradesh. (*ii*) The plains goat, originating from Jamnapari and the hill types, are named after different regions such as *Marwari*, *Mehsana*, *Zalawadi*, etc. (*iii*) The Deccan Plateau goat originates from the migratory varieties of goats in plains. The large, big-framed and long-eared Jamnapari type has lost its stature on the plateau due to the paucity of food. This group consists of mixed types, and extends to the plateau from the plains. This group includes some of the hair growing varieties as well. (*iv*) The Barbari, Surti and Yelchikeri types are reared for home milk supply by the labour and artisan classes who do not possess any land. This goat has its origin in the small Arabic milking goat.

Goats can be maintained in any part of this country, as the animals are characterised by a great capacity for adapting themselves to a variety of conditions. It is the most economical animal and can subsist on grasses and leafy herbage. The so-called destructive habits of goats are due to the irresponsibility and poverty of the herders, who take advantage of their habit of browsing, and indiscriminately allow the herds to destroy vegetation.

In order to make these animals more useful to the livestock industry of the rural areas, the present non-descript and scraggy types will have to be replaced by goats which will yield higher quantities of milk, meat and mohair, so that their maintenance could be adjusted to the mixed farming economy and substantially contribute to the milk and meat supply.

Plan of improvement

The Council, with the object of initiating research in developing new efficient breeds of goats, has formulated a plan of breeding goats for the production of fine hair and has also sponsored breeding programmes for evolving high milk-yielding strains. The experimental breeding of goats for the production of mohair has been undertaken at the sheep breeding research stations in Uttar Pradesh and Bombay States. The results of preliminary investigations in mating the local goats with the imported Angora breed have shown that the country cannot only rear the mohair yielding pure-bred type but raise an animal far superior to the imported variety. Whereas the local goats yield a coarse hair which can only be used for ropes and belts, the mohair can be utilised for the manufacture of fancy fabrics. The yield of hair from goats in the hill areas is half to one pound per year, while the clip from Angora weighs from four to six pounds a year. The graded progeny at the research stations and among the local goat owners, where the imported Angora is being introduced, is yielding softer, finer and more lustrous fleeces, indicating that the country can develop a new industry both as regards the production of raw material and a new variety of fabric.

The Council has recommended that this project be undertaken in the hill areas of Kashmir, Himachal Pradesh and Uttar Pradesh. The Deccan Plateau affords, in many places, suitable conditions for raising Angora goats and the States concerned are formulating research schemes to introduce this new breed.

Jamnapari buck

Meat and milk

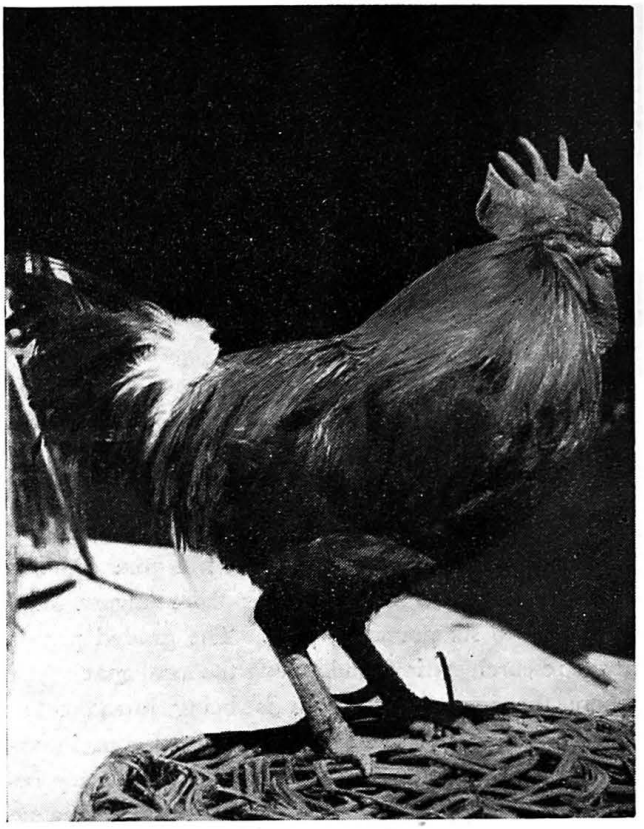
Simultaneously, the improvement of goat for meat and milk production is receiving attention. Research programmes for selective breeding among the Jamnapari breed in Uttar Pradesh have been undertaken to evolve high milking type. Outstanding goats are yielding as much as six to eight pounds of milk a day, the highest record being as much as 12 pounds per day. An exploratory trial in breeding the imported Saanen goats is underway at the Sheep Breeding Research Station, Poona. The results obtained so far have shown that, with due care, this breed which is one of the highest milk-yielding varieties in the world, can be reared and there is every chance of evolving a suitable milk breed of goat for the hill regions of the country.

Imported Angora goats

Poultry

by

S. G. Iyer



Rhode Island Red

THERE are about 69 millions of poultry in India, the worth of which is Rs. 104.7 million. The bulk of the population consists mainly of the ordinary mongrel indigenous fowl whose average annual egg production is only 52 per bird as compared to an average annual egg production of 130 per bird in many of the foreign countries. The number of pure bred fowls, *e.g.*, White Leghorn, Rhodes, Plymouth Rock, Minorcas, Australops, etc. is hardly one per cent of the total fowl population.

Research has been undertaken for investigation and control of contagious diseases of poultry, systematic development of the village poultry by up-grading with pure-bred cockerels, and introduction of improved methods of marketing of poultry and eggs after grading and processing.

Breeding

By selective breeding for over 10 generations, an improved strain has been evolved whose average annual egg production is about 150, while individual hens have laid up to 234 eggs. The size of the egg has also been considerably improved. If it is finally proved that the improved Indian fowl is suitably acclimatized to withstand the local field conditions, there will be absolutely no need for importing exotic breeds of poultry.

Grading

The grading up of low production stock of Indian fowls by cocks of the foreign breeds such as White Leghorns and Rhode Island Reds have proved to be the quickest method of improving an ordinary flock as regards egg production and egg size.

Sex-linkage

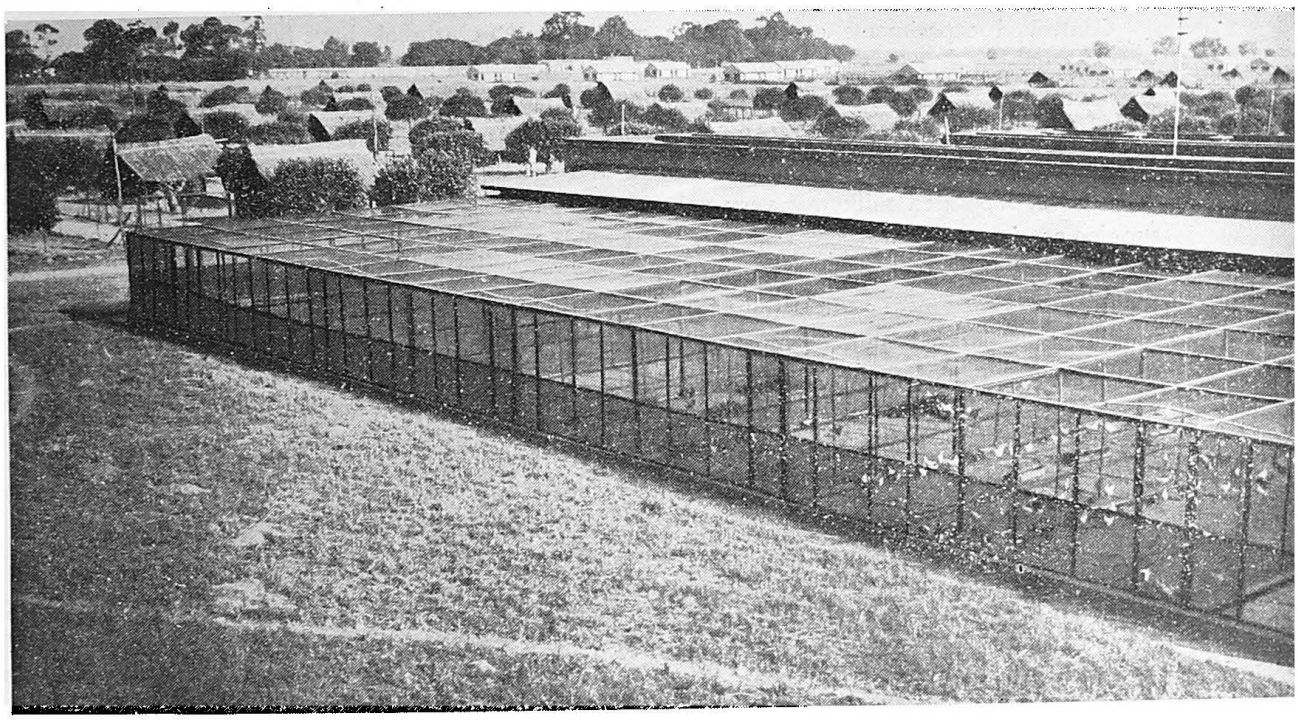
The sexing of day-old chicks is an important aspect of economical poultry enterprise. Suitable crosses using Barred Plymouth Rock imported from the U.S.A. and a variety of Indian fowl birds have been produced in which the sexes of the baby chicks can be accurately determined as the two sexes have different colours. The auto-sexing of chicks is bound to prove of immense economic value to the poultry industry in the country.

Inheritance

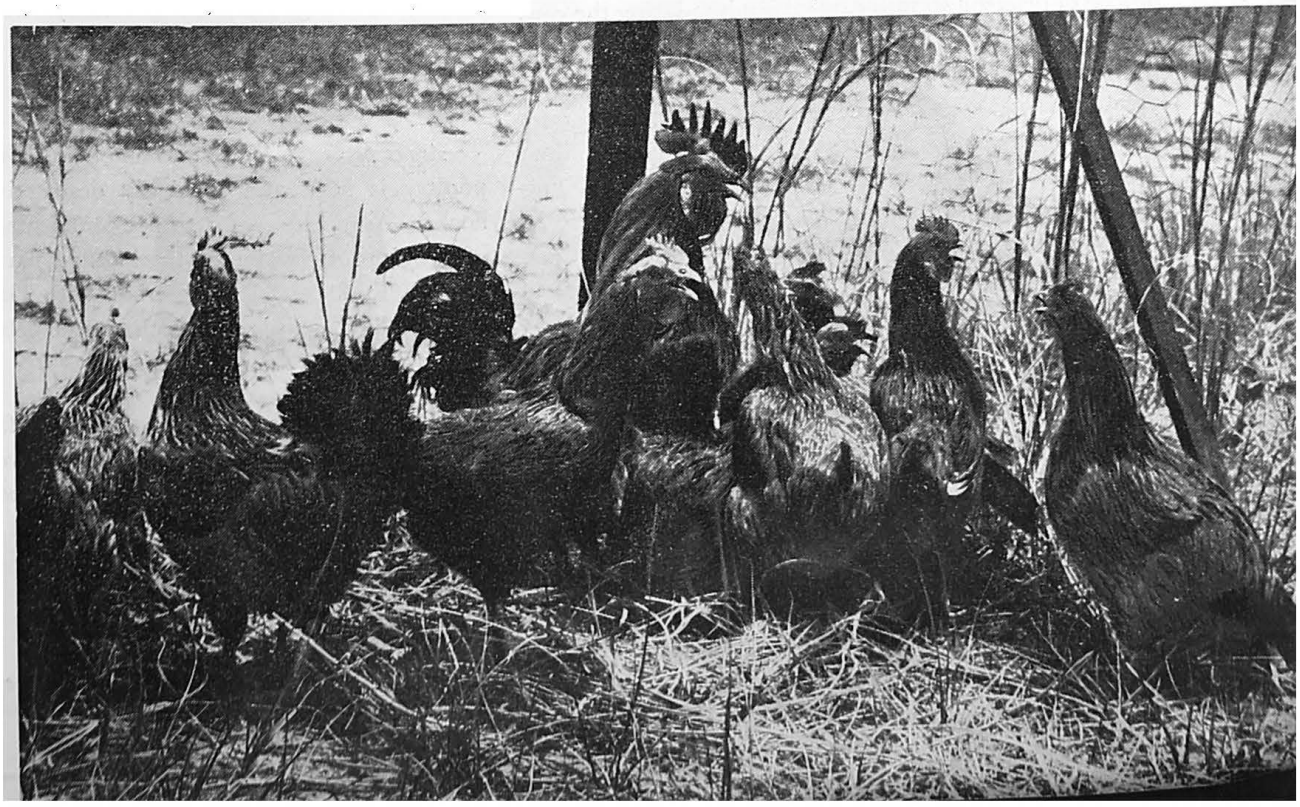
Experiments on the inheritance of morphological characters such as smut (slaty) under colour in Rhode Island Red fowls, and feathers on the shanks and feet of White Leghorns have revealed that these characters, which are considered as hereditary defects, are not associated with egg laying qualities.

The various factors responsible for the determination of fecundity of birds, early sexual maturity, high rate of production, non-broodiness, lack of winter pause and persistency of production have been studied under Indian conditions.

A view of the poultry farm at the Indian Veterinary Research Institute, Izatnagar



A group of healthy birds



Nutrition

The nutritional studies on growing chickens and laying hens have been undertaken to discover the best and cheapest methods of making good the deficiencies which are found associated with typical cereal rations.

Protein supplement

Controlled experiments on the value of different protein supplements in the poultry rations revealed that a cereal ration plus one per cent common salt, in conjunction with liberal amounts of green food and limestone, was unsatisfactory both for growth and egg production, separated milk was very valuable protein supplement in poultry rations, and that meat offals as protein supplement gave almost as good results as separated milk, soyabean meal and earthnut cake both proved inferior to separated milk or meat offals as protein supplements. Attempts have been made to obtain suitable supplements which are at present being wasted. In this connection, the effects of the substitution of cereals by treated cow manure, mango seed kernel and *jaman* seed meal, have been studied and have been found to be economical. *Jaman* seed meal has been found to have a depressing effect on egg production but has no deleterious effect on the growth of chickens.

Technology

One of the major causes of egg spoilage in India is the development of embryos in fertile eggs especially during the summer season when the eggs become inedible after about 48 hours storage. Methods have been elaborated to minimize these losses considerably. These are: defertilisation, lime sealing and oil dipping. The process of defertilisation is carried out by placing the eggs in warm water bath for 15-30 minutes. When properly controlled, this treatment has been found to have great beneficial effects on the storage life of eggs. Limes sealing is accomplished by soaking the egg in lime water for about 18 hours prior to preservation. Oiling is accomplished by dipping the eggs for one minute in egg-processing oil kept at room temperature. All these methods have great potentialities.

Canning

In canning chickens, the use of lacquered cans is preferred. The addition of common salt greatly helps in the development of metallic taste even in the contents of the lacquered cans. The addition of salt is, therefore, not recommended in canning chickens.

Pathology

The control of Ranikhet disease of fowls by a cheap and safe vaccine has been achieved. This vaccine has no adverse effect on either the growth rate or egg production.

India was so long free from Salmonella infection. Outbreaks have been recorded recently in widely separated areas. In each case, the spread of the disease has been controlled and eradication of the infection made possible through improved blood test.

The existence of carriers responsible for perpetuation of fowl cholera from one season to another has been brought to light. The preparation of more satisfactory vaccines is in progress.

Avian Leucosis Complex is a disease almost new to India. The nature of filterable fraction (virus), capable of experimental transmission in susceptible birds, has been studied.

In recent years numerous reports on the incidence of fowl-pox have been received; in chicks the mortality is very severe. An English strain of pigeon-pox virus has been used as a vaccine with satisfactory results. The suitable age for vaccination has been found to be six weeks and above.

Nutritional deficiencies

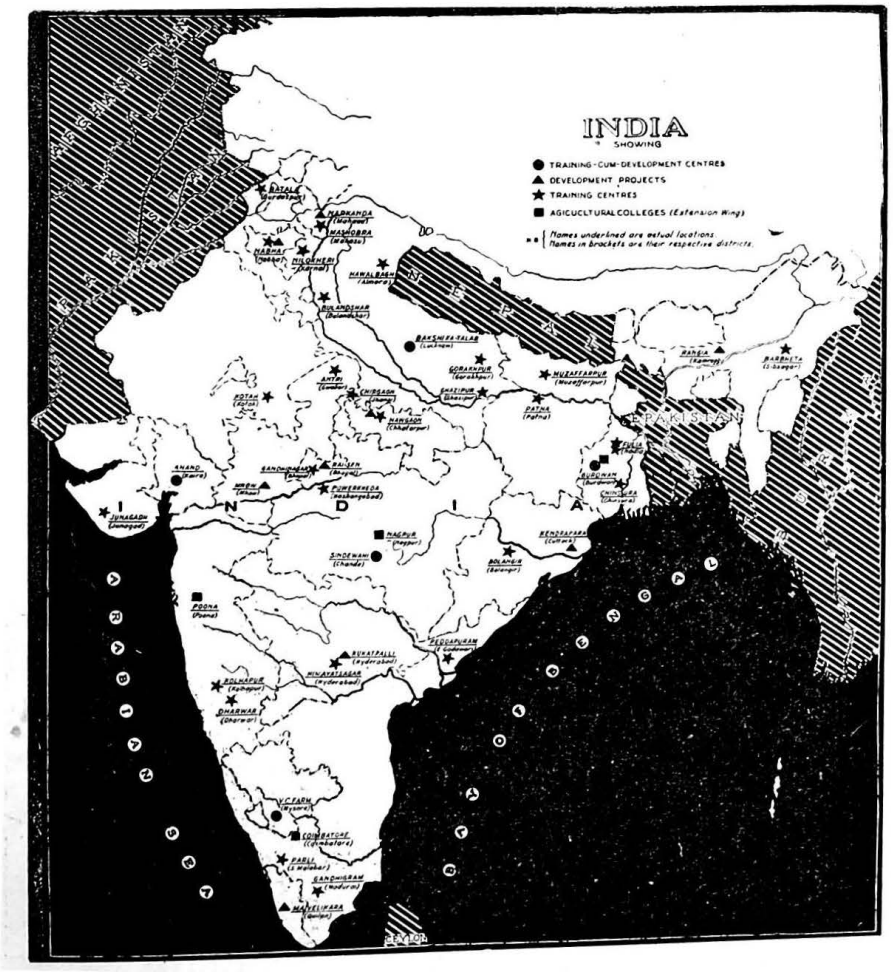
The presence of vitamin A deficiency in chickens at several large farms was confirmed by assaying the vitamin A content of livers from birds showing typical lessons resulting from this deficiency in the eyes and throats.

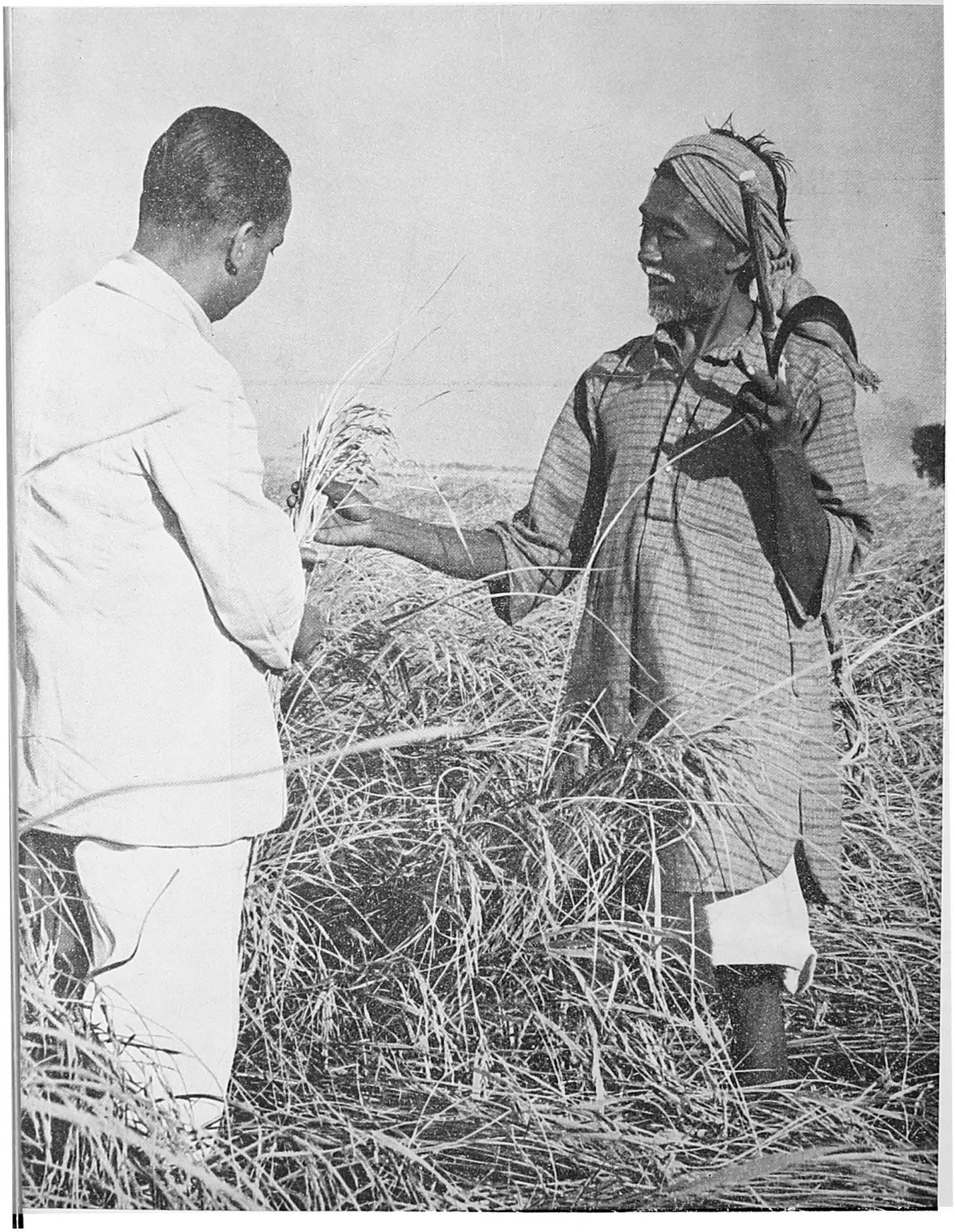
Ticks

Argas persicus is quite common in houses wherever poultry is kept and is highly destructive to poultry flocks. Application of a 10 per cent aqueous suspension of *Derris* root powder on the infested parts of the body kills all the ticks. Recent trials with Gammexane by dust methods or by dipping the affected birds in 25 per cent solution proved effective.

Data on the economics of poultry farming reveal that poultry keeping will be lucrative only if at least 25 per cent of the total eggs produced are sold or utilised as hatching eggs.

GENERAL


INDIA
SHOWING
TRAINING-CUM-DEVELOPMENT CENTRES
DEVELOPMENT PROJECTS
TRAINING CENTRES
AGRICULTURAL COLLEGES (Extension Wing)
Names underlined are actual locations
Names in brackets are their respective districts.
INDIA
PAKISTAN
BHUTAN
NEPAL
CEYLON
BAY OF BENGAL
ARABIAN SEA



Helping the farmer to help himself

Grasses & fodder crops

Sudan grass

by

B. P. Pal

GRASSLANDS constitute the major source of animal nutrition in India.

Studies in experimental ecology of grasslands in Bombay indicate that mere protection can increase the carrying capacity of grasslands considerably. The effectiveness of this methods was also demonstrated on *usar* soils by experiments carried out in Uttar Pradesh. Although the principle has been accepted in the working plans of the Forest Departments, more experimental data are needed especially on the vegetational changes, the forage production and time required for full recovery, to formulate a rational grazing policy.

Studies on successional changes in the grassland vegetation are important in assessing the efficiency of a given treatment at any stage of development. A number of such studies have given us a picture of the nature of succession in the grasslands of the Deccan and certain alluvial soils and *usar* soils. The investigations, however, should necessarily be extended to different grassland types, keeping in view the operation of biotic factors like grazing, burning, cutting, etc.

On the management side, it has been shown that production and the carrying capacity of degraded grasslands could be considerably improved by a suitable system. Grazing experiments confirmed the superiority of rotational grazing. Although recommended and practised to some extent, the system has not become popular as it involves expenditure on fencing, etc.

Information on improvement of grasslands through reseeding and manuring is meagre. The policy of reseeding natural grasslands in many areas is likely to be suicidal as it involves ploughing up operations. The response of grasslands to manuring has also been studied. The application of bone-meal and groundnut cake singly, or preferably in combination, were effective while farmyard manure did not show encouraging results. In Madhya Pradesh a 50 per cent increase in forage yields was reported with the application of 100 lb. of ammonium sulphate.

Studies on grasses and legumes

The first serious attempts to study grasses and legumes on a country-wide basis may be said to have started in the beginning of the present century. Exotic grasses such as Guinea grass, Napier grass, Rhodes grass, Para grass, Sudan grass and Teosinte introduced quite early in the century were given extensive trials during the last 25 years and have now been adopted in various parts of the country. Para grass, although introduced in 1894, has, however, received attention only during the last few years as a material for reclaiming water-logged areas. Recent studies indicate that the grass could be successfully employed for utilization of alkaline areas. Selection of thin Napier grass has been found suitable for semi-arid regions.

Among the recent grass introductions may be mentioned Blue Panic (*Panicum antidotale*), Giant star grass (*Cynodon plectostachywm*), Love grass (*Eragrostis sp.*) and Natal grass (*Tricholaena rosea*). Kudzu, both Japanese and tropical, Hubam sweet clover, common vetch, velvet beans and *Centrosema pubescena* are some of the notable legume introduction. Blue Panic has been reported as being extremely drought resistant

and suitable for semi-arid regions. It shows remarkable recovery after each cutting, a character which makes it a good pasture grass. Giant Star Grass has been found useful as a drought resistant grass. Love Grass and Natal have shown promise.

A potentially very valuable contribution to the forage crops in India in recent years has been the Kudzu vine. Introduced in 1925, its potentialities have been acknowledged only recently. The prolific growth, quality and quantity of fodder and capacity to remain green in summer without irrigation are some of the qualities useful in reclamation of the eroded areas. Trials have shown that the vine is most suited to alluvial soils. Seed production being poor vegetative propagation has been recommended. An Assam variety of Kudzu remains green even during the severe winter of north India and provides fodder almost throughout the year. Tropical Kudzu appears to be a failure in north India but suits the humid southern regions.

Another interesting addition of fodder has been that of Hubam sweet clover, a close relative of the Indian legune *senji*. Trials have shown that the introduction of this clover is likely to be of great significance because it can be used as a fodder-cum-green manure crop in an intensive rotation of maize-wheat, under irrigation, without losing a crop as is the case with other green-manure crops.

Indigenous grasses and legumes

Amongst the indigenous grasses that have shown considerable promise the following may be mentioned: *Dichanthium annulatum, Cenchrus ciliaris, C. setigeus, Iscilema laxum, Sehima nervosum, Setaria palmaefolia* and *Phalaris minor*. *Cenchrus ciliaris*, the famous *anjan* of the Punjab, and *kolukattai* of Madras have become quite popular in these States. At Sirsa the white hairy *anjan* yielded better than other strains, and has been successfully introduced in the forest grasslands of Madras. *Setaria palmaefollia*, a grass suitable for humid regions, especially under shade, has been reported as showing a record protein content amongst the Indian grasses. *Phalaris minor*, a naturalised species in India, has attracted attention especially for its possible use as a fodder in rice-growing tracts.

Amongst the indigenous legumes, *Alysicarpus regosus, Indigoefera glandulosa, Desmodium diffusum,*

Various fodder crops produced at the Indian Veterinary Research Institute, Izatnagar

Glycine javanica and *Dolichos lablab* have gained prominence in recent years. *A. rugosus* and *D. diffusum* have been suggested as useful legumes for introduction in the natural grasslands. The latter species has also shown promise as a cover crop for soil conservation in Bombay. *Indigofera glandulosa* has been reported to make a good mixture with grasses. A wild form of *Dolichos lablab* forms closely inter-woven mat and has been suggested to be useful for soil conservation.

Two other aspects of the study of the grasses and legumes, *viz.*, their role in building up soil fertility and in preventing erosion have received attention only in recent years. The pioneering experiments at the Indian Agricultural Research Institute have indicated that the inter-polation of a grass-legume ley of one, two or three years duration maintains a higher fertility as compared to continuous cereal rotation. The Rhodes Grass and lucerne ley appears to have a future as a dual purpose crop. Among soil binding grasses Blue Ponic has been reported to be the best and may be useful in soil conservation work.

There is evidently a vast scope for study of grasses and legumes, not only as a forage crop, but also in respect of their fertility improving and soil conservation ability.

Fodder crops

The important fodder crops other than grasses under cultivation in India are *jowar*, maize, cowpea, soyabeans, *Guą pillipesara* in the *kharif* and berseem, lucerne, *senji*, oats, rape and turnips in the *rabi* season.

Kharif fodder

Jowar is grown extensively as a dual purpose crop for grain and fodder, but as an exclusive fodder crop, it is grown only in a few States like Bombay, Madras and Punjab. The most popular varieties in Bombay are *Sunhia* and *Nilwa* in *kharif* and *Shalu* in winter.

Maize as a fodder crop is quite popular in Northern India. No selection work appears to have been done with the exception of PF1, PF2 and PF3 selections, of which PF2 has remained as a standard fodder variety. Although known as a vegetable and pulse crop, the fodder value of cowpeas was only recognised early in the present century. The variety S1 is popular. More recently the studies on cowpeas have led to the selection of K. 397, K. 700, K. 385 and K. 782 of which K. 397 has become a standard variety. Soyabeans is an excellent fodder crop for tiding over the fodder scarcity in November ; the yellow and chocolate varieties were found to be superior. *Guar* as a drought resistant fodder crop has found favour in Punjab, where F.S.2 selection has been recommended. Pillipesara (*Phaseolus trilobus*) has been a popular fodder legume taken after the harvest of paddy in Madras State.

Rabi fodders

The introduction of berseem in 1904 by Henderson solved the problem of fodder supply in *rabi* under irrigated conditions. Various aspects of the crop like cultural and manurial requirements and its role in crop rotations have been studied. The seed production was observed to be maximum when the crop was left for seed after the third cut. The introduction of lucerne dates back to the early 19th century. Although popular as an excellent fodder for horses, its use as a cattle fodder has not been extensive. As a drought resistant fodder, *senji* has been in cultivation in Punjab since ancient times. The selection F.S. No. 1 has been quite popular. Oats are grown to some extent especially as a fodder for horses. Amongst the fodder crops other than grasses and legumes may be mentioned the white-leaved Japan rape and turnips recommended in Punjab.

Agricultural economics

by

G. D. Agrawal

REPORTS of various committees and commissions provide valuable information relating to the research work in agricultural economics carried out in India during the last several decades. The main contribution of the committees and commissions is in the nature of ground work. They have achieved some success in specifying the exact nature and, in some cases, the magnitude of the economic problems of Indian agriculture. Generally speaking, no original investigations were conducted by these bodies.

Non-official agencies

The non-official institutions, mainly the universities, have conducted some original field investigations in addition to the compilation of information from the official records. Socio-economic surveys of villages and rural life constitute the majority of field studies made so far.

Generally speaking, the Indian universities have no separate departments for agricultural economics. The Bombay University was the first to open a separate section of agricultural economics in their School of Economics and Sociology. The work actually started in October 1945. Some of the important investigations conducted there are: working of the Growth of Food Crops Act and the levy system in Gujerat, accuracy of official agricultural statistics and of the method of collecting data, co-operative farming in Maharashtra, farm economy and indebtedness in Karnatak, economics and social conditions of the *Halis*, resources of cultivators of the economic holdings, land transfers, obstacles to Grow-More-Food, economic survey of Saurashtra, working of the Agricultural Produce Markets Act, and the nature and extent of non-farm employment. A special section of rural economic research was established in the Delhi School of Economics in 1952.

Considerable amount of research in agricultural economics has been done under the auspices of the Gokhale Institute of Politics and Economics.

The Indian Society of Agricultural Economics was started in 1939. It differs materially from similar academic bodies in so far as a permanent nucleus staff is maintained by it for pursuing a regular programme of research.

Investigations with wide coverage

The first attempt to conduct investigations with a wide coverage was made in 1933. An enquiry into the cost of production of sugarcane and cotton in the main sugarcane and cotton growing tracts of India was conducted under the auspices of the Indian Council of Agricultural Research in 1944 villages of 23 districts in seven provinces and in three states, *viz.*, Hyderabad, Mysore and Baroda during 1933-37. The enquiry was not confined to the cost of production of sugarcane and cotton but covered other crops as well. In 1932-33 studies were undertaken on the mechanical cultivation, costs under different conditions, economic life of tractors, implements, etc.

The Gokhale Institute of Politics and Economics conducted a survey of agricultural economic conditions with particular reference to farmers' costs and returns on 620 holdings in 30 villages of Wai *taluka* of Bombay State during 1936-38. On the request of the Government of Bombay, the Institute also carried out in 1946 a study of the economic benefits of irrigation supplied by the Godavari and Parvara canals.

Experiments on mixed farming in Uttar Pradesh, Madhya Pradesh, etc. during 1941-44 indicated a general increase in income from cash and food crops as compared with holding on which no milch cattle were kept.

The Council financed an interesting experiment to study the economics of farming on equal-sized holdings under identical conditions but under different systems of farming, *i.e.*, peasant farming, tenant farming, co-operative farming and collective farming. The returns of the holding farmed under peasant proprietorship were the highest.

Marketing

Since the establishment of the Central and State Departments of Agricultural Marketing in 1935, very valuable information has been compiled on supply, demand, markets, marketing practices, methods of storage, transport, prices, spread-over of marketing costs, etc. for a large number of agricultural commodities. The Economic Research Section of the Indian Central Jute Committee has been conducting an investigation into the economics of jute growing in Assam, West Bengal, Bihar and Orissa since 1948.

Agricultural economic studies

Among the Agricultural Colleges in the States, the one at Poona is the oldest to have a separate chair in agricultural economics. Pioneering research on farm cost accounts and family budgets of farmers was undertaken by it as early as 1929. The post-graduate classes in agricultural economics were started at the Government Agricultural College, Kanpur, in 1945, but a full-fledged research-cum-teaching section under the charge of an agricultural economist was established in October, 1953. Some of the notable research activities of the section are: analyses of agricultural cost data on nine State farms for a period of 20 years from 1930-50, working of co-operative farming in Uttar Pradesh, agricultural economic survey of villages in different regions of Uttar Pradesh, farm cost studies on cultivators' holdings including four model holdings set up on a State farm, cost of production of jute, economics of orchard keeping in hills and the relative profitability of cotton and alternative crops in cotton growing tracts of Uttar Pradesh.

The Ministry of Agriculture, Government of India, has a Directorate of Economics and Statistics and there are Directorates or Bureaus of Economics in many of the States, *e.g.*, Madras, Bombay, Punjab, Uttar Pradesh and West Bengal.

The Punjab Board of Economic Enquiry, formed as early as 1919, initiated a study of farm accounts and family budgets of farmers.

In Uttar Pradesh, an enquiry into the cost of cultivation on 12 holdings in 16 villages of various districts of the State was conducted by the Directorate of Economics and Statistics in 1948-49. An enquiry into rural incomes in about 100 villages, selected by the random sample method is also in progress.

An economic survey of 118 villages was carried out in Hyderabad State during 1949-51.

Till recently, the Agricultural Credit Department of the Reserve Bank of India was mainly concerned with the compilation of co-operative statistics and consolidation of secondary data on rural problems. During 1948-49 an assessment of the Grow-More-Food Campaign in a few *talukas* of Bombay State was undertaken. A survey of agricultural indebtedness in two *talukas* of Sholapur district was conducted on the basis of applications filled by 4865 cultivators in 1948 for a scaling down of their debts.

Agricultural marketing

by

M. B. Ghatge

INVESTIGATIONS into the improvement of marketing conditions of agricultural, animal husbandry and allied products are of recent origin. In 1928, the Royal Commission on Agriculture in India for the first time drew attention to the deplorable agricultural marketing conditions in the country and made a number of recommendations for improving the situation. The recommendations were subsequently endorsed by the Central Banking Enquiry Committee. As a result, the Government of India constituted the Directorate of Marketing and Inspection in 1935 under the aegis of the Indian Council of Agricultural Research. Simultaneously marketing organisations were set up in the then provinces with the help of Central subsidy and also in the Indian States, for looking after marketing under the guidance of the Agricultural Marketing Adviser to the Government of India.

In a predominantly agricultural country like India, one of the essential pre-requisites to the improvement of national economy is the development of marketing systems for agricultural and animal husbandry products on sound scientific lines. The problems in agricultural marketing are socio-economic in character and of diverse nature and to solve them, all the aspects are required to be tackled carefully in an organised way.

In view of this, the Directorate has undertaken to enquire into the conditions of marketing of the major agricultural and animal husbandry products by survey and to publish a report on each commodity, bringing out the weaknesses in the existing marketing systems and making detailed suggestions for their improvements. It also fixed grade standards. For this, a large number of representative samples of agricultural and animal husbandry products from the several and widely distributed markets are analysed with a view to finding out the prevailing defects in quality, and then suitable uniform standards are drawn up for general adoption by the producers and the trade. The Directorate initiates development work on improved methods of marketing.

Marketing surveys

Till the setting up of the Central and State Marketing Organisations in 1935, practically no information was available as to how, in what manner and at what cost the farmer's produce was distributed in different parts of the country. Similarly, there was no information on what share of the consumer's rupee went to the producer, how our products behaved in foreign markets, what improvements were needed in orderly marketing, etc.

The investigations (surveys), undertaken covered all aspects of marketing such as supply, utilisation, demand, prices, preparation for market, methods and costs of assembling, classification, grading, handling and transportation, wholesale and retail distribution, processing and manufacturing, weights and measures, methods of storage and storage losses, quantity and type of seed required and research done and required to be done for improving marketing directly and indirectly.

The Marketing reports of the investigational surveys published by the Directorate on various commodities brought out the prevailing weakneses enabling thereby to know how and where steps should be taken to bring about improvement in the existing system for the benefit of producers. So far 72 all-India reports, brochures and bulletins have been issued covering more than 40 commodities and subjects. The more important of these relate to wheat, rice, gram, barley, eggs, *ghee* and other milk products, potatoes, milk, fish, grapes, citrus fruits, bananas, pome and small fruits and pineapples, cattle, sheep and goats, hides, skins, coffee, sugar, coconut and coconut products, linseed, groundnuts, castor seed, rape seed and mustard, sesamum and niger seed, cashewnuts, arecanuts, cardamom, lac, tabacco, sann-hemp, wool and hair, bristles, etc.

Grading and quality control

The surveys brought to light the absence of any standard relating to quality and marketing practices, which mainly stood in the way of the producer realising adequate price for his produce in the primary markets. They further revealed that the absence of any quality standards and the presence of various malpractices resulted in: (*i*) a complete lack of confidence between the buyer and the seller; (*ii*) a considerable waste and financial loss in packing and transport of useless material by rail, road, river and sea; and (*iii*) a discredit for the products of this country in foreign markets.

These considerations led to the fixation of grades and standards and the passing of the Agricultural Produce (Grading and Marking) Act. The former necessitated collection and analyses of a large number of representative samples after taking into account the varieties and types of each commodity in different producing areas of the country and the existing practices, followed by the trade in grading them as also the practices in foreign countries. The necessity thus arose of consulting and persuading the producers and traders for adoption of the standards prescribed.

Legislation

To give stability to the grades, the Agricultural Produce (Grading and Marking) Act was passed in 1937. The Act provides for the fixation of grade standards for agricultural and other products and for the grant of certificates of authorisation to suitable private persons or corporate bodies to undertake grading on the basis of these "Agmark" standards and in accordance with the various grading and marking rules and instructions issued under the Act, both for internal and external trade.

So far "Agmark" standards have been drawn and notified for a number of distinctive grades of different commodities and their varieties; their number is about 110. Tentative specifications also exist for 71 more varieties and products, while for some more they are being drawn up. The more important items that are covered by these standards are wheat, rice, *ghee*, edible oils, butter, eggs, fruits, potatos, cotton, sann-hemp, tobacco, bristles, essential oils, wool, goat hair, etc. Experimental grading stations were also run by the Directorate in the early stages to demonstrate grading technique and the advantages of grading. With the exception of wheat, coffee, myrobalans, skins and sugar, practically all important commodities have been brought under the "Agmark" grading. The value of the products graded so far has risen from a little over one crore of rupees in 1940 to more than Rs. 17 crores in 1953. The articles that are "Agmarked" in larger quantities are *ghee*, oils and eggs for internal consumption and tobacco, sann-hemp and bristles for export. In respect of commodities whose grading is based on chemical analysis like *ghee* and oil, the authorised packers are required to maintain a well equipped laboratory and a qualified chemist. Grading equipment and "Agmark" grade designation labels are supplied by the Directorate which also arranges for supervision during different stages of grading and marketing. The grading stations as also the laboratories are also subjected to periodical inspection by the Central and State Marketing staff and specially qualified Quality Control Inspectors. As a further check, a number of samples of graded produce are also collected from wholesale and retail markets, producing centres, etc. all over the country, for the purpose of verification of quality at the Government Control Laboratories maintained for this purpose at Kanpur and Rajkot. In the case of export commodities like tobacco and sann-hemp, further inspection and checking are arranged before shipment. As stated earlier, the "Agmark" grading is voluntary. However, the quality of exports of tobacco, sann-hemp and bristles is compulsorily regulated according to "Agmark" standards.

The results of grading are exceedingly satisfactory and encouraging. Apart from the fact that the graded articles command a good premium over the ungraded produce, the consumers are assured of a product of a standard quality and purity. Foreign markets also demand products with "Agmark" grade certificates. Banks and other financing agencies find the "Agmark" grading certificates useful for making advances.

Developmental work

Apart from the work of grading and standardisation, the marketing survey reports incorporate a large number of practical suggestions for improving the existing market practices in regard to individual commodities. These recommendations are passed on to the State Governments concerned for implementation.

In the case of heavy staples like wheat, linseed groundnuts and copra, as also for groundnut, linseed and castor oils, standard contract terms have been drawn up in order to encourage trading in clean and unadulterated products. A bill was also prepared for their compulsory adoption and circulated to all State

Governments. As, however, this became a Central subject, the inclusion of the Standard Contract Terms in the bye-laws of the trade organisations has been provided for in the Forward Market Regulations Act recently passed by the Government.

In order to eliminate malpractices in marketing, create confidence between the buyer and seller, and ultimately improve the bargaining power of the producer, a model bill for standradisation of market practices in the primary markets was circulated in 1938. As a result, Regulated Market Acts are now in force in several States, like Bombay, Madras, Madhya Pradesh, PEPSU, Punjab, Hyderabad, Mysore, Madhya Bharat, etc. Steps are also being taken by other States to enact and enforce similar legislation. So far 403 markets have been regulated in the country.

On the initiative of the Directorate, the Central Government enacted Standards of Weights Act in 1939. Based on these standards, several State Governments, *viz.*, Bombay, Madhya Pradesh, Punjab, Bihar, Hyderabad, Mysore, Delhi, Ajmer and Saurashtra have enacted Weights and Measures Acts for regulating weights and measures and are enforcing the same. The remaining States also have been requested to take similar action.

The development of co-operative marketing has been all along one of the most important subjects for investigation. An all-India review on this subject was undertaken and a report containing a number of recommendations was published in 1943. The States are being advised constantly that it is essential to have farmers' co-operative societies for the purpose of selling their produce at reasonable prices. This will eliminate the chances of traders contriving to promote their own ends at the expense of the farmer. If possible, co-operative arrangements for processing, storing and also for providing finance should be made.

The importance of licensed warehouses in the development of marketing and in the matter of helping the producer in securing short-term credits and holding the produce for better prices, has been stressed in the various marketing survey reports. States like Bombay, Madhya Pradesh and Madras have passed the Licensed Warehouses Act and are making efforts to enforce it.

In order to eliminate wastage in storage and in transit, experiments on a commercial scale for evolving standard containers for eggs were conducted in Madras, Travancore-Cochin, Uttar Pradesh and few other States. The results have been communicated to the States who have profited from them.

Dissemination of market intelligence is necessary to keep the producers and interested parties posted with up-to-date information regarding prices, stocks, etc. A market news service has been initiated.

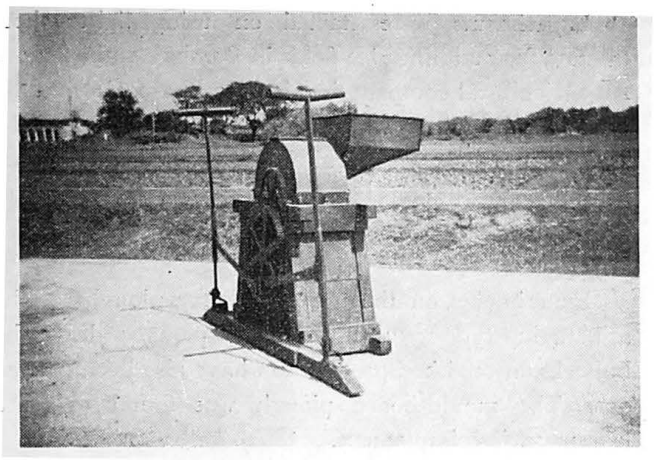
The compulsory grading schemes for sann-hemp and tobacco have been responsible for the development of fresh foreign markets for these commodities and also for stabilising the existing markets. Steps have been taken for the initiation of similar schemes in respect of other export products like wool, bristles, essential oils, etc. Standard samples of different commodities prepared in accordance with "Agmark" specifications are being sent from time to time to various countries with full information about availability, price, etc. with a view to exploring the possibilities of developing markets there.

With a view to developing the fruit products industry and particularly ensuring hygienic production and standardisation of fruit products, the Directorate administers the Fruit Products Order, 1948. Under the Order, all manufacturers of fruit products above a minimum limit are permitted production only under a licence from the Agricultural Marketing Adviser and on the fulfilment of certain conditions prescribed in the Order with regard to hygiene, sanitation and standards. Intensive inspection of factories is also undertaken to see that the provisions of the Order are complied with, and a large number of check samples are collected from all over the country and analysed for ensuring quality standards.

Agricultural Implements

by

R. V. Ramiah



Hand operated Japanese type paddy sheller

THE Royal Commission on Indian Agriculture made the following comment regarding agricultural implements in this country:

> "Agricultural implements in India are on the whole well adapted to local conditions. They are within the capacity of the draught oxen, comparatively inexpensive, light and portable, easily made and, what is perhaps of even greater importance, easily repaired, and they are constructed of materials which can be readily obtained. In spite of these advantages, there is undoubtedly very great scope for improvement in the light of modern knowledge of soil conditions".

The Commission also stated that the improvement of existing agricultural implements and machinery offered a more promising field than the introduction of new implements or machinery. Discussing the possibilities of power machinery in Indian agriculture, they stated that although it had a limited scope, a systematic investigation on the economics of power cultivation might be conducted. At the time of the visit of the Royal Commission, there were many States which did not have a Division of Agricultural Engineering.

The Department of Agriculture, Madras, appointed a Research Engineer in 1928 at Coimbatore. Many other State Governments appointed agricultural engineers and a Research Division of Agricultural Engineering was added to the Indian Agricultural Research Institute in 1945. The work of the Departments of Agricultural Engineering in the States may be broadly classified into four groups. They are:

(i) Well-boring and installation of tube-wells;

(ii) Installation of Persian wheels, water lifts and pumping sets;

(iii) Tractors and power machinery used for land reclamation and follow up cultivation; and

(iv) Research and introduction of improved agricultural implements, machinery and methods.

Tractor and power machinery

Less than one per cent of the cultivated land in India is now being farmed by power machinery. The Burmah-Shell Oil Storage and Distributing Company of India conducted experiments on the eradication of weeds by deep ploughing in the black cotton soils of Bombay State and also in parts of Sind in 1936. The Indian Agricultural Research Institute conducted some experiments on the eradication of *kans* in Bhopal State during 1946-48 by using heavy tractors. Deep ploughing to more than 14 inches in depth, followed by a leguminous crop to build up soil fertility, was recommended as a suitable measure for land reclamation and eradication of *kans* in Central India. The activities of the Central Tractor Organisation in this field, in the States of Uttar Pradesh, Madhya Pradesh, Bhopal, Madhya Bharat and Punjab, are quite well-known.

Experiments have been conducted on using groundnut oil and mustard oil for operating stationary diesel engines required for pumping or rural processing. It has been found that starting of these engines should be done on diesel fuel, while the indigenous vegetable oils could be used for running the engines.

Experiments were started on using light wheel tractors for puddling rice fields in Bombay and Madras. An agricultural company in Madhya Bharat successfully used wheel tractors for puddling wet land extensively. The Department of Agriculture, West Bengal, has used medium wheel tractors for reclaiming water-logged areas.

Indigenous or country ploughs

Experiments on the use of country ploughs of the soil stirring type *versus* mould-board ploughs drawn by bullocks for seed bed preparation have also been carried out. The mould-board plough was found to be a labour saving implement.

A collection has been made of all the different types of country ploughs from the several States of India for study and experimentation. It is found that the Sholapur plough is the heaviest, needing two to three pairs of bullocks. The country ploughs used in Bengal and Orissa for rice cultivation are broad like a duck-foot and have a flat base and can only work in fields under water to bring about a puddling effect.

The Naini Agricultural Institute conducted tests and trials on several types of yokes used for two bullocks in different parts of India. The Madras Department of Agriculture developed a harness for a single bullock to pull agricultural implements in field operations.

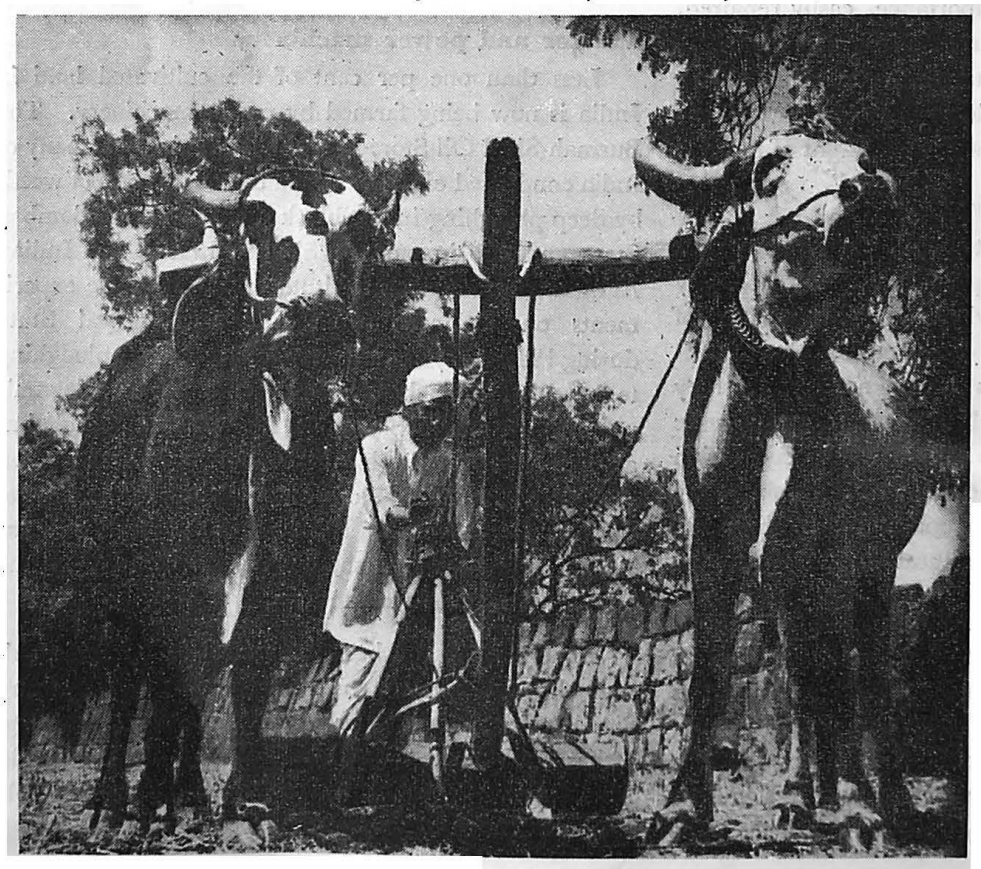
Mould-board ploughs

Attempts have been made from time to time to introduce soil-inversion ploughs of the western type in Indian agriculture. The Victory ploughs from the United Kingdom and the Meston type ploughs have found popular use in different parts of the country.

The Bakhar or the indigenous blade-harrow of India has been improved scientifically so that the depth of operation can be controlled. It is known in different parts of the country by the names of "Guntaka", "Bakhar" and "Kunti".

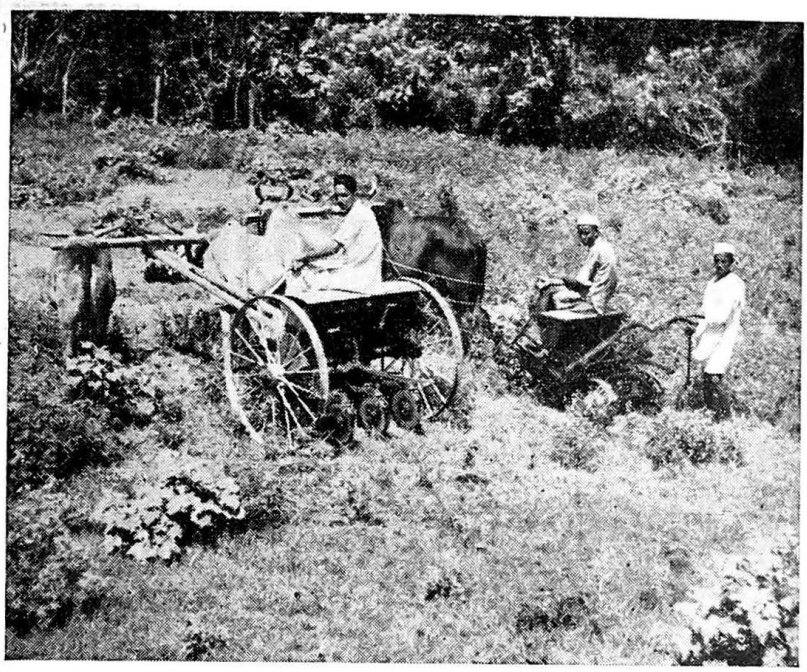
Seed drills

A mechanical seed drill has been designed and used in a limited way in the peninsular India. Cotton seed drills have been designed in Punjab. The "nail" or the attachment of a tube behind a country plough has been used in the north for seeding small grain crops. Single-row seed drills for jute have been developed and distributed in the jute growing areas of Bengal. Single row groundnut planters have also been developed.



The implement is an improved type

Cotton seed drill



Bullock drawn seed drills

Water lifts

The indigenous water lift of the north has been completely replaced by a lift with " links and buckets ". The Persian wheels have been introduced in the eastern and southern States. The mechanical efficiency of the water-lifts has been measured from time to time with a view to improving their performance. Some patents have also been granted for a few such improvements. The indigenous *mhote* or the single bullock water-lift of South India, has been improved by using chains buckets and by introducing the " Roll Easy Ball-Bearing Mhote Wheel ". Centrifugal pumps driven by electric or engine power are becoming increasingly popular and very common in Uttar Pradesh, Madras and Mysore.

Processing machines

The hand driven chaff cutters for processing fodder have become popular in the northern States. Bullock operated chaff cutters have been evolved and are in use in some places. A pedal-driven chaff cutter was designed in Madras. Extensive experiments have been conducted on improving the performance of rice mills with a view to securing a higher turnover of unbroken and unpolished rice kernels. The Japanese type rice shellers, both the hand operated and power driven types, have been found to be efficient. The wooden roller sugarcane crushers have been replaced completely by crushers with iron rollers. Barns for curing tobacco and cold-storage arrangements for potato have also been developed. Graders for eggs, potatoes and oranges have been designed and built. The Department of Industries, Bombay, has been marketing a scientifically designed single bullock *ghani*, with a concrete base and steel structure, which gives the lowest draught. The Technological Laboratory of the Indian Central Cotton Committee at Bombay has designed a hand-cum-power driven table type cotton gin.

Country carts

The wheels of the country carts have been subjected to tests. In some parts of Uttar Pradesh, complete cart wheels made in steel (riverted) have become popular. In a few organised farms, carts with rubber-tyred wheels are in use.

Statistics in agriculture & animal husbandry

by

V. G. Panse

MODERN statistical method based on the theory of probability and providing a most powerful means for efficient planning of observational and experimental programmes and for unambiguous interpretation and summarization of the resulting data may be said to have been born with the publication of R.A.Fisher's book on *Statistical Methods for Research Workers* in 1925. The simple, yet elegant, arithmetical procedures developed by him brought this rigorous mathematical tool within easy reach of the vast body of research workers in various fields, whose mathematical attainments are not high enough to enable them to work through the underlying complex theory, but who can nevertheless master these procedures for use in their own problems with confidence. The Indian Council of Agricultural Research, which was established in 1929, was quick to grasp the potentialities of the new science in its application to agricultural and animal husbandry research which it was its function to promote and co-ordinate. A Statistical Section made a modest beginning in 1930 at the Headquarters of the Council and the Council also started making generous financial grants to the Statistical Laboratory, which was established at Calcutta about the same time. These grants were continued for several years and helped in placing the laboratory on a firm foundation and developing it into a flourishing statistical centre that it has become now. During the quarter of a century that has elapsed since statistical research, theoretical and applied, has been pursued in India with great vigour over a wide front.

Statistical methods in agriculture

The first impact of the new statistical method on agricultural research workers was the realization that the old type of field experiment with inadequate replication and no randomisation and without any systematic procedure for interpreting the results was of little or no value in providing unequivocal information on the questions posed. This deficiency was strikingly brought out in Vaidynathan's report published in 1934, on the analysis of manurial trials in India. Consequently, experimental designs such as randomised blocks and latin squares propounded by Fisher and embodying the principles of replication, randomisation and local control, and later developments mainly due to Yates such as factorial arrangements involving confounding, which has broadened the inductive basis of experiments, and various incomplete block designs for comparing a large number of varieties, have been taken up by agricultural workers enthusiastically. The earliest experiments of the new type, a varietal trial of rice in 12 × 12 latin square was reported as early as 1931. The first factorial experiment with three varieties of potatoes under three manurial treatments was laid down at the instance of the Statistical Laboratory, Calcutta, at the Visvabharti Institute of Rural Reconstruction at Sriniketan in 1931. The Indian Council of Agricultural Research also encouraged the adoption of modern experimental designs directly by making it a condition for all the research schemes financed by it that the lay-out plans of the experiments should be approved by the Council's Statistician. This emphasis on scientifically planned experiment was in a large measure responsible for a rapid spread of the statistical methods in the planning of field experiments and in the analysis of their results. In 1936, the Council published *A Hand-book of Statistics for use in Plant Breeding and Agricultural Problems* written by F.J.F. Shaw. This book did much to create interest in the use of elementary statistical methods in agricultural research, but has been out of print for some time. At the instance of the Council, V.G. Panse and P.V. Sukhatme have written a new book entitled *Statistical Methods for Agricultural Workers* which the Council has published recently. The role of the Council in thus guiding agricultural research along the right channels through well-planned experiments at the State farms and

rendering help to experimenters in the proper use of statistical method forms an important chapter in the history of agricultural research in India.

Side by side, theoretical research for extending the scope of confounded factorial designs and of incomplete block designs to deal with more complicated experimental requirements and introduce greater flexibility in their availability by constructing new classes of such designs has been going on and already a wide range of new designs have been added to the list. It must be pointed out, however, that the mathematical construction of new designs has outstripped practice, and the task of sifting these designs in order to study their utility in the field lags far behind. A line of work which may have a bearing on the analysis of experimental or observational data is the method of non-parametric tests which is being developed in recent years.

The more practical aspects of laying out and analysing experiments have, of course, received considerable attention. Uniformity trials on different crops, for example on rice, wheat and cotton, have been conducted in order to study optimum size and shape of plots and blocks and the efficiency of alternative experimental designs. Methods for analysing data from various experimental lay-outs rendered incomplete due to one or more plots missing or their yields getting mixed up accidentally have been evolved. Tables for widening the scope of tests of significance in connection with experimental comparisons have been prepared. Methods of studying the economics of manuring by the use of appropriate response curves in conjunction with experimental data have been described. In studying the responses of cotton to fertilisers, the importance of planning manurial trials in such a way that the response curves could be determined adequately has been emphasised. A critical summarization and review of past data with the help of statistical methods, apart from their use in bringing forth results suitable for making practical recommendations, is an important aid or even a pre-requisite in the scientific planning of further experimental work. Such reviews of work on manurial requirements of cotton and rice in India has been published. The information on the responses of major food grains to different types and amounts of fertilisers has also been summarised.

It is well-recognised that for translating scientific discoveries in agriculture into general practice, they must be given a trial under ordinary farming conditions. A strong case for conducting experiments on a representative sample of cultivators' fields to verify the results of past experimental research was first made by Stewart in his important report on *Soil Fertility Investigations in India* published in 1947. To implement his recommendations, the Indian Council of Agricultural Research has sanctioned several projects in different States. These projects included 50 three-plot experiments per district on an important crop. It was later realized that the scope of three-plot experiments was very much limited in securing information on responses to different kinds and quantities of fertilisers, and sets of four, five and six plot arrangements have been worked out by the Statistical Branch of the Council. A proper choice of treatments in such experiments is very important in order to reconcile the extreme simplicity of lay-out, essential for securing the cultivators' co-operation, with the requirements of modern field experiments, and the subject is attracting increasing attention. A large programme of experiments on cultivators' fields has been launched recently in the various Community Project Areas.

Considerable advance has been made in making available modern experimental designs and other statistical techniques to meet the needs of the plant breeder through the work done at the Institute of Plant Industry, Indore. The randomised block and split plot designs have been adapted for field trials of plant breeding material, and the replicated progeny row and compact family block lay-outs have been developed. The feasibility of applying such designs for efficient testing in plant breeding has not only been demonstrated, but it has also been shown how the difficulties resulting from very small and variable amounts of seed could be overcome satisfactorily. Apart from efficient method of field testing, a factor of fundamental importance in plant selection is the recognition of the fact that only a part of the observed variability in a plant population is genetic, the rest being environmental. The breeder's success depends upon the critial choice of material containing a high degree of genetic variablity and exploiting it to the maximum extent possible. How the genetic components of observed variability could be estimated by taking the regression of progeny mean on parental value has been shown, and the importance of selecting plants on their deviations from plot means rather than on their own values has been explained. Alternative methods of estimating genetic variability have also received attention.

The study of genetics of quantitative characters is of basic importance to the plant breeder, since the economic characters for which he breeds are all quantitative. Such a study is necessarily statistical, and a new approach to this subject has been envisaged through the use of appropriate genetic models, which help to bring out the effects of the number of segregating genes, the magnitude of their action, the modification due to dominance and the influence of environment on progress due to selection. The scope of this study has recently been amplified by using models suited to a wider range of genetic situations. In the light of the study of quantitative inheritance and the development of appropriate designs for field trials, the systematic handling of the plant breeder's problems of choice of material, method of selection and maintenance of improved strains have been studied.

Some work has been done on scoring linkage data from different sources for estimating recombination fractions. Haldane's formula for estimating the distances between loci on chromosomes from the study of recombination fractions between factors has been modified. The complete scoring system for the simultaneous segregation of recombination fractions from three point data giving the simultaneous segregation of three factors has been formulated.

Statistical method in animal husbandry research

In the field of animal husbandry research, introduction of ideas of modern experimental design has been a slower process owing to certain inherent limitations of the experimental material, such as the cost of maintaining experimental animals and the long duration of some of the experiments as in a cattle breeding programme. Mainly through the lead given by the Indian Council of Agricultural Research and with the co-operation of animal husbandry workers, the need for planning animal experiments on statistical principles is being increasingly recognized by the research workers in this field. The designs employed are relatively simpler, such as randomised blocks and latin squares, but more complicated designs like the switch-back and switch-over designs are occasionally employed. Examples are provided in the study of the effect of muscular exercise on the production of semen of bulls and in the comparison of different feeds in a poultry research project in Madhya Pradesh. The problem of the optimum size of experiments for testing sera and vaccines has been examined. It may be added that the ground has now been prepared for a systematic use of efficient designs in animal husbandry research. A problem of considerable importance in this field is standardisation of methods of sampling and measuring animal products in connection with breeding, nutritional and other investigations. The study of sampling and measurement of quality of wool which has been undertaken by the Statistics Branch in collaboration with the Sheep Research Station at Poona has revealed that the usual method of measuring fibres gives biased results and drawing of bunches of fibres is preferable to drawing single fibres for this purpose.

Critical statistical analysis of data collected in animal breeding projects has proved valuable in focussing attention of animal breeders on the need for a continued statistical appraisal of the results of breeding and, what is probably more important, of planning of breeding programmes in such a manner that they will lend themselves to this appraisal. A study of the 10 years' data of a goat breeding project at Etah in Uttar Pradesh was a landmark in this type of assessment and showed clearly that the year to year improvement recorded in the herd was not due to the genetic improvement of the stock through selection but due to extraneous factors. Since then, analyses of data from cattle and sheep breeding projects at different farms have been undertaken by the Statistical Branch of the Council and this have yielded results of immense value. They have indicated, as in the Etah goat breeding project, that the genetic improvement was much less marked than was believed to be, or was even absent, and have brought out the need of providing adequate numbers of breeding animals, especially on the male side, to allow scope for efficient selection through properly planned progeny testing in each generation. As an aid to the selection of animals with a superior genotype, an application of the discriminant function technique to selection in poultry has been demonstrated.

Among other data, the statistical analysis of milk composition data collected by the Allahabad Agricultural Institute helped to show that a margin of tolerance has to be allowed in fixing standards of quality for milk on account of natural variation due to species and breeds of animals and seasonal and regional factors. Statistical techniques have also been applied in the study of nutritional requirements of cattle. The growth of calves fed on ordinary and special diets in the Pusa herd has been studied by fitting parabolas to the average weekly weights of the calves under the two treatments.

Sample surveys

Striking progress has been recorded in the application of statistical sampling techniques for the improvement of agricultural statistics, especially of production. Statistics of crop acreages and land utilization have been collected in temporarily settled areas traditionally through the *patwari* agency by complete annual enumeration. In the permanently settled areas like Bihar, Bengal and Orissa there is no such agency and acreage data have been little more than guess work. To remedy this situation, the Indian Statistical Institute has carried out sample surveys for the estimation of area under jute and rice in Bengal using a single stage sampling design with square or rectangular areas called grids, usually of 2½ acres size, marked on the cadastral survey maps as the units. More recently, the Indian Council of Agricultural Research designed and conducted sample surveys for estimating crop acreages in Orissa through a two-stage sampling plan, villages forming the first-stage units and clusters of fields the second-stage units, the sampling of villages being done with a probability proportional to their size. An important feature of the Orissa survey was the sampling of cadastrally unsurveyed areas, which are the most backward in the country, through villages as the sampling units. The selected villages were completely enumerated with the help of sketch maps prepared by the investigators, who were trained in land measurement and mapping. These surveys have demonstrated very successfully that sampling can be employed for accurate estimation of the acreage of at least the major crops. In order to improve the reliability of the acreage statistics provided by the *patwari*, the Indian Council of Agricultural Research has proposed rationalisation of supervision on a sampling basis. Sampling has also been recommended for securing accurate early forecasts of crop acreages by getting the *patwari* to carry out the crop inspection over a selected portion of the area in his charge before a prescribed date.

Forecasting of crop yields have been based everywhere on the notions of normal yield and the seasonal condition factor. The process is essentially subjective, and objective estimation of yield must mean some form of sampling, involving the determination of the yield of the sample plots by the so-called crop-cutting. The Board of Agriculture in India had recommended as early as in 1919 that crop-cutting experiments for determining normal yield should be located in randomly selected villages, fields and plots.

The method of crop estimation involving the appointment of special field staff and a field procedure requiring a very small sample cut with a special apparatus and a delicate technique has not been generally accepted by the State Governments. To secure permanent adoption, the sampling method must fit into the existing administrative structure and take cognisance of the fact that departmental staff is familiar with crop cutting procedure. An approach on this basis was made in 1942-43 for estimating the yield of cotton. The sampling was multi-stage, the sub-divisions of a district forming the strata within which villages were selected as the first-stage units, and fields and plots of a size used in departmental crop-cutting, *viz.*, 1/10th acre, were taken as the second and third stage units respectively. The only really new feature of the survey was that the selection of all these sample units was made by strict randomization. With the success of survey, the method was extended to other crops and areas. Commencing from 1943-44 the Statistical Branch of the Indian Council of Agricultural Research developed sample surveys on food crops with the result that in 1952-53 the yield of food crops was estimated by this method on over three-fourths of the acreage under food crops in India and the yield surveys have become an annual routine in most of the States. The surveys provide not only the State yield with a high precision, but district yield also with a reasonable margin of error. These crop surveys are perhaps the largest sample surveys carried out anywhere in the world.

A considerable amount of experimental work for judging the optimum size and shape of plots in crop-cutting surveys has been done by the Indian Statistical Institute and the Indian Council of Agricultural Research. The latter on the basis of numerous tests has shown that plots of a small size give an over-estimation of yield. The bias resulting from plots of a very small size, at least under Indian conditions, is recognized by all workers, but there is no unanimity of opinion concerning the stage at which the bias becomes negligible.

The sample survey technique has been extended to other crops such as oilseeds, sugarcane and spices as also to the estimation of livestock numbers and the catch of marine fish. In inquiries on the cost of production of crops, the principle of random sampling of the holdings or fields, in respect of which the cultivation account is to be maintained, is now acknowledged

to be essential for ensuring representative estimates of the cost of production. A pilot survey on these lines for estimating the cost of production of cotton, groundnut and *jowar* sponsored jointly by the Indian Council of Agricultural Research, Indian Central Cotton Committee and the Indian Central Oilseeds Committee was carried out successfully in Akola district of Madhya Pradesh in 1952-53. A similar survey on sugarcane is in progress in six States. A sample survey for estimating the cost of production of milk in the urban and rural areas of Delhi is being conducted and has provided some interesting results already.

The sample survey technique found a somewhat noval application in the assessment of the results of the Grow More Food Campaign, which was launched about the year 1947. The object was to find out what additional production had resulted from the large-scale adoption by farmers of measures like improved seed, manures and fertilisers, reclamation of land by tractor ploughing and more irrigation. The frame for sampling consisted of the farmers who had received the benefit of one or more of these measures, and crop-cutting surveys on a sample of these farmers' land provided results of very considerable value. With the help of these results, more reliable criteria have been evolved than the rough and ready yardsticks that were in use for judging the results to be expected from the campaign.

Side by side with these practical developments, a considerable amount of research in sampling theory has also been carried out. This has included the study of topographic correlation and of cost and variance functions, development of formulae for estimating efficiency of alternative procedures of sampling and critical study of non-sampling errors.

Training in statistics

With the rapid expansion in the application of modern statistical method in agricultural research, there arose insistent demand for the training of research workers in the competent use of this method and of professional agricultural statisticians for meeting the wider needs of the agricultural and animal husbandry departments in the States and Central Institutes. The Statistical Laboratory at Calcutta gave such training initially on an individual basis and later on developed regular courses in theory and general application of statistics in which agricultural statistics was included. The Indian Council of Agricultural Research also provided training facilities for workers deputed from time to time by the Central and State Governments. In 1945, regular training courses in agricultural research statistics were instituted by the Council. They aimed at meeting the needs of trainees of two categories, viz., research workers in agriculture, animal husbandry and allied sciences whose primary interest was not statistics but for whom a correct use of statistical methods was important in connection with their research, and persons who wished to study the statistical science with particular reference to its application to agriculture with a view to acquire proficiency as agriculture statisticians.

Statistics is a science of method. It can broadly be considered in two parts, pure and applied. The pure part which included statistical theory with the related mathematics is being increasingly taken care of by universities as far as training of statisticians is concerned. The applied part requires a knowledge of the subject to which statistics is to be applied as much as of statistical theory. Therefore, any institution which has for its objects imparting training and carrying out research in agricultural statistics must be in active contact with the technical problems in agriculture, animal husbandry and agricultural economics such as those dealt with in the various projects sponsored by the Indian Council of Agricultural Research, Central Institutes of Agricultural and Animal Husbandry Research, Central Commodity Committees and Departments of Agriculture and Animal Husbandry in the States. The Statistical Branch of the Indian Council of Agricultural Research is eminently fitted for imparting training in statistics to various categories of workers in agriculture. A number of agricultural and animal husbandry research workers and professional statisticians have already received this training.

Indian Society of Agricultural Statistics

The statement given above will be incomplete without a reference to the Indian Society of Agricultural Statistics and the part it has been playing since its inception in promoting the study of and research in agricultural statistics. The Society was founded in 1947 with the object of bringing together statistical and agricultural workers for discussion of problems of common interest. The Society has been doing useful work in furthering the cause of agricultural statistics, and also in disseminating results of statistical research relating to agriculture and animal husbandry.

Extension activities

by

S. C. Roy

IT is well-known that agricultural production in India is low. In order to increase it, the Royal Commission on Agriculture in India, appointed in 1926, came to the conclusion that it was necessary to have intensive research. This research, carried on for the last 25 years under the auspices of the Indian Council of Agricultural Research, has yielded important results. Nevertheless, not until very recently, no co-ordinated attempt was made to carry the results of this research to the cultivators' fields and thus increase production and improve the standard of living in rural areas. No doubt, the States tried to disseminate the knowledge of these results of research but, due to various reasons, the efforts remained unsystematic and unco-ordinated and the progress was consequently far from satisfactory.

Extension services

It was to remedy this state of affairs that the Indian Council of Agricultural Research, at a joint meeting of its Boards of Research and Extension in May 1951, discussed at length the importance of establishing a nation-wide extension service. The Indian Council of Agricultural Research, accordingly, addressed all the States asking them to form extension organisations, together with a State Board of Extension and district extension boards in each State. In a resolution passed at this meeting, it was emphasised that no attempt for a successful extension service could be made without the co-operation of the enterprising farmer, who was the pivot of prompt and effective agricultural reform, and that such non-official persons were to be enlisted to supplement the extension activities of official organisations.

When the Council was considering its plans to intensify the introduction of known results of research, which would help in stepping up the per acre yield in the intensive zones where rainfall and irrigation were assured, a delegation from the Ford Foundation of America visited this country to discuss ways and means by which their services could be utilised. The Council took advantage of this opportunity and after negotiations with this body, started five pilot Extension Training Centres together with 10 development projects, each with 100 villages, early in 1952 in co-operation with the Ford Foundation and the States. The object of these Training Centres was to train personnel in the technique of approach to the farmers and in extension methods. It was the intention to equip the trained extension worker with practical knowledge of application of improved practices and the results of research in the field. The first of these Training Centres was started at Bakshi-ka-Talab in Uttar Pradesh in May 1952, and the other four followed rapidly one after another at the V.C. Farm in Mysore, at the Burdwan Farm in West Bengal, at Anand in Bombay and at Sindewahi in Madhya Pradesh. Ten additional pilot development projects of 100 villages each were also started during the year in Rangia (Assam), Patna (Bihar), Kendrapara (Orissa), Markanda (Himachal Pradesh), Mhow (Madhya Bharat), Obeidullaganj (Bhopal), Nowgong (Vindhya Pradesh) and Mavelikara (Travancore-Cochin).

While the Training Centres were designed to train skilful workers in extension methods, oriented with a new philosophy of learning and teaching people by practical work, the object of the pilot development projects was to step up production per acre, mainly bearing in mind the central features of our rural economy, *viz.*, (a) the low productively of land, (b) lower rates of capital formation and *per capita* income, (c) a rapid increase of population and consequent unemployment, (d) excessive dependence on land and lack of subsidiary occupation, and (e) the general low standard of living. In short, the object of the pilot projects was to tackle the problem of Indian poverty, not as an isolated factor but as an integrated problem covering all aspects of rural lives.

Emphasis on agriculture

As the vast majority of our people live in the villages and are engaged in the age-old profession of farming, agriculture naturally offers the largest scope for employment and livelihood. As long as agriculture does not improve, the level of production from land will remain low. As in the ultimate analysis, everything comes from land, whether it is food for human consumption or raw materials for the various industries, in this new endeavour to improve the villages of the pilot projects in every respect, the greatest emphasis was placed on agriculture. The central aim of the Plan was, therefore, to improve upon the low average yield per acre and to ensure a higher return to the farmers.

While the Indian Council of Agricultural Research steadily progressed on its new venture, the Planning Commission took up reconstruction of the country as a Welfare State and was immediately faced with the problem of adequate trained personnel to execute their programme of community development. As the Council had already taken up the training of extension personnel and the development of the country by concentrated projects and blocks, the training of extension workers required for the implementation of the Community Projects was entrusted to the Council.

The Planning Commission correctly appreciated the fact that any programme which aimed at raising the standard of living of the people must necessarily start at the village level and such a programme, as was contemplated by the Indian Council of Agricultural Research, must be directed towards the improvement of all aspects of village life. The Council was, therefore, entrusted with the task of training the requisite number of multi-purpose village-level workers or *gram sevaks* required for the Five-Year Plan. For the first Five-Year Plan alone, over 15,000 persons have to be trained by 1955-56; this does not include the superior administrative personnel.

More training centres

In order to fulfil this undertaking, the Council started 29 new Extension Training Centres at Nabha (PEPSU), Antri (Madhya Bharat), Bolangir (Orissa) Bairagarh (Bhopal), Jorhat (Assam), Himayatsagar (Hyderabad), Nilokheri and Batala (Punjab), Nowgong (Vindhya Pradesh), Junagarh (Saurashtra), Powerkheda (Madhya Pradesh), Dharwar and Kolhapur (Bombay), Mavelikara (Travancore-Cochin), Kotah (Rajasthan), Patna and Muzaffarpur (Bihar), Fulia I, Fulia II and Chinsurah (West Bengal), Peddapuram (Andhra), Palghat and Gandhigram (Madras), Mashobra (Himachal Pradesh), Chirgaon, Hawalbagh, Ghazipur, Bulandshahr and Gorakhpur (Uttar Pradesh).

These Training Centres, similar to the five started prior to the coming of the Community Projects scheme, were also designed to impart training in agriculture, public health, education, veterinary aid, co-operation, panchayat work, village housing and extension methods. With the decision to coveer one-fourth of the country with National Extension Service blocks during the first Plan period (1951-52 to 1555-56), further facilities for training were required and nine more centres are to be added to these 34 centres, in addition to the one started in Kashmir.

These Training Centres have by now trained 5,347 persons, while 2,023 are still undergoing training. The staff of all these Centres has been carefully selected and has during these years, gained a great deal of experience in conducting the training programme. Of the existing 35 centres, 18 are single shift, each designed to turn out at least 80 persons every year, and 17 are double-shift each intended to turn out at least 160 persons every year.

Enlarged scope of training

Soon after starting these Extension Training Centres, it was realised that it was essential for every village level worker to have a good training in agriculture and land economy. It was, therefore, planned to arrange for at least one year's basic agricultural trainihg for the multi-purpose village worker prior to the six months' course at the Training Centre. With a view to carrying out this programme, 56 new basic agricultural schools were sanctioned for the whole country, 22 of which were to be added to the Training Centres themselves as basic wings and 22 were to be started as new institutions, while 12 of the existing schools in various States were to be reorganised for this purpose.

The scope at the Training Centres is now also being enlarged by the addition of workshops to 20 of these Centres in addition to the existing facilities for training in smithy and carpentry. Besides, 25 wings for training in home science are being added to 25 of these Centres for training women workers for the development blocks. The problem of orientation of agricultural graduates in modern extension methods has also been considered and with this end in view five extension wings have been sanctioned to five agricultural colleges in the country.

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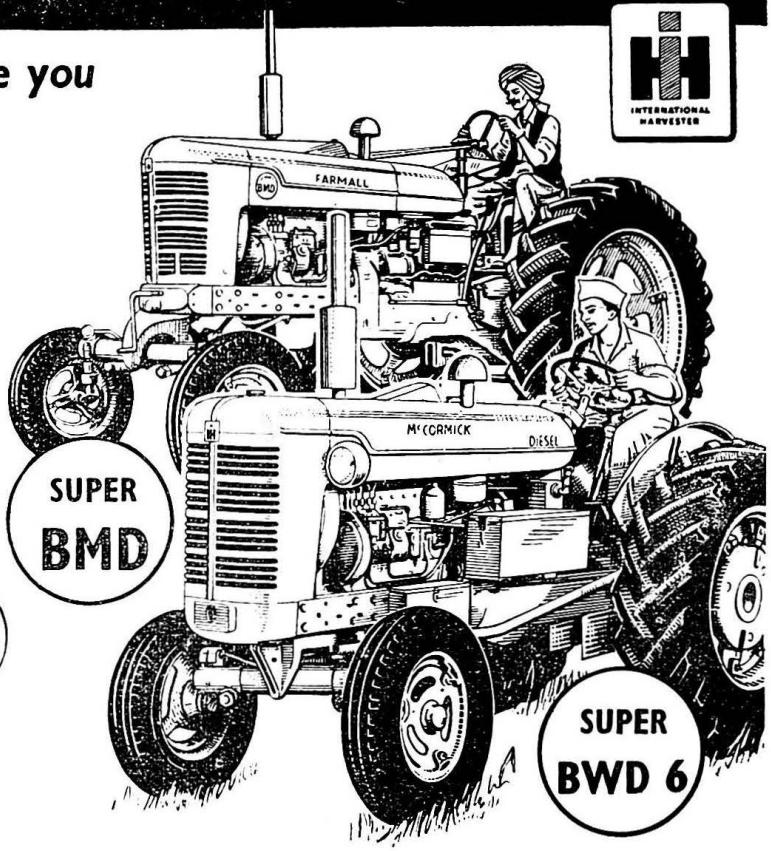

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